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ASSESSMENT OF TECHNICAL CONDITION AND REINFORCEMENT OF STRUCTURES ARCHITECTURAL MONUMENT "BUKHARA WATER TOWER"

Vakhidov M.M.[1] , Safarov U.I. [2]

Doctor of Technical Sciences, Professor [1]
Bukhara Engineering Technological Institute.

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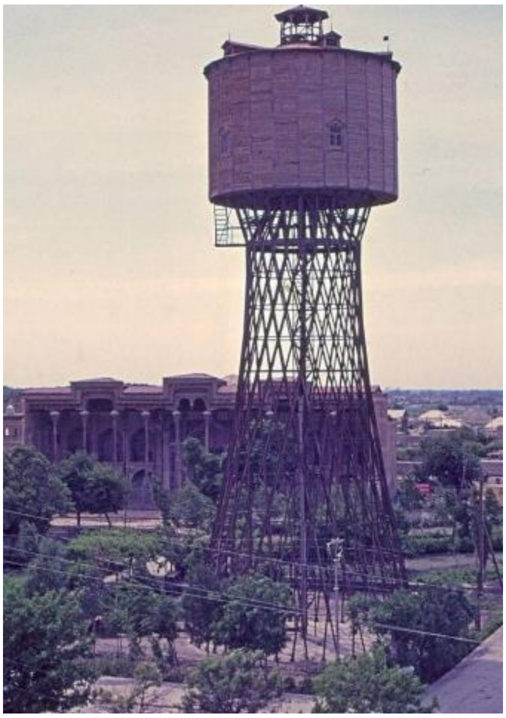
Abstract: The article examines the state of the Bukhara water tower, built from an interesting rod mechanical system. In order to use the architectural monument for tourism, the structure of the structure has been studied, constructive solutions have been developed to strengthen it, improve the strength, reliability and durability of the tower.

Keywords: water tower, structure, structure, technical condition, foundation, support ring, corner, metal gusset, metal belt, deformation, stability, reinforcement.



The architectural structure "Bukhara Water Tower" is striking in its majesty, delicacy (photo 1-5). The water tower of the rod system of the famous scientist Shukhov was built in 1927-1929. For many years, the water tower served as a water supply system in Bukhara, until in 1975 its wooden casing was burnt down as a result of a fire, and the water reservoir warped. After that, the tower was no longer in operation.

Photo # 1. General view of the Bukhara water tower after construction; at a height of +25.2 m there was a water tank, which had a maximum diameter of 6.5 m, its height was 4.2 m. Above the tank there was a platform for observing the surroundings, to which one could climb a spiral staircase.

Photo # 2. General view of the water tower in the 1970s

Photo # 3. General view of the tower in the 2000s during its use as a restaurant (lower tier) and an observation deck (upper tier)

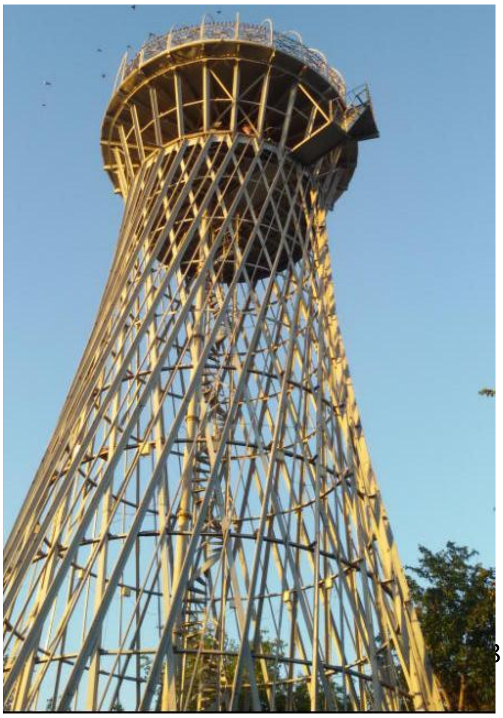


Photo # 4. General view of the tower in the 2000s during its use as an observation deck

Photo # 5. General view of the tower at 1.05. 2018; it is currently being reconstructed in order to organize an observation deck

The water tower is a lace-like mesh structure of the rod system. Shukhov managed to give an ordinary water tower an extraordinary engineering and architectural sophistication and modern technical beauty.

In the late 90s it was recognized as a monument of historical heritage, and in the early 2000s it was restored, an elevator was installed in the tower. The architectural structure was later used as a restaurant, but then, due to the breakdown of the elevator, it was empty.

Surveys showed that the walls and ceilings of the basement of the tower, where pumping equipment was installed at one time, the metal floor beams are subject to severe corrosion, on the one hand, and on the other, there is currently no need for the basement, therefore, during the last reconstruction, we recommended close the tower's emergency basement.

Photo 6. Fragment of the uncovered 3-stage foundation of the tower (uncovered depth of 3 m); height and width of the 1st lower step 60 and 230 cm; height and width of the 2nd middle step 50 and 50 cm; the height and width of the third upper step are 130 and 50 cm.The total width of the basement sole is 660 (/ 230 + 50 + 50 / x2) cm, its total height is 240 (60 + 50 + 130) cm.

The opening of the underground part of the structure showed that the total width of the foot of the 3-step foundation (see photo # 6) is (230 + 230) + (50 + 50) + (50 + 50) = 660 cm, its total height is 60+ 50 + 130 = 240 cm. The height of the upper part of the foundation from the ledge to the bottom of the metal support ring is 130 cm; the width of the ledges in each direction is 50 cm. The height of the upper cut of the foundation, on which the metal support ring is installed, is 30 cm.

The average compressive strength of concrete, determined by the non-destructive method using the Onyx-2.5 device, is 15.4 MPa (strength class is almost B12.5). There are no signs of corrosion or other damage on the surface of the foundation.

Measurements showed that the actual height of the structure from the floor (planning mark) to the ceiling of the observation deck is 25.2 m.At the level of the support ring, the diameter of the lower ring of the mesh structure is 14.4 m.At the level of the observation deck of the ring, the diameter of the upper ring of the tower is 10 m , and the diameter of the lower ring (elevator platform) is 8 m.

Since people will climb to the observation deck, it was therefore necessary to clarify the useful standard load. Calculations showed that the total load applied to the uppermost observation deck with a diameter of 9 m will be 25.4 tons. At the same time, 52 oblique elements of the architectural structure, consisting of metal equal-sided coal No. 120 and serving as racks are sufficient to lift above the specified load.

The width of the metal support ring is 30 cm, the initial thickness is 20 mm, at the present time it is 4 mm at the place of opening, i.e. corrosion destroyed metal with a thickness of 20-4 = 16 mm. Between the paired coals (No. 120) there are “gussets” more than 1 cm thick. The total design thickness of the vertical rib of the support ring is 42 mm.

a)

b)

Photo 7. Support ring, consisting of two coals (No. 120) and gussets are attached to the foundation with bolts installed every 92 cm on both sides of the ring (a - general view, b - bolt separately;now after corrosion 19 ... 23 mm, at the same time its initial size was 25 mm)Studies have shown that the support ring is fixed to the foundation using anchor bolts with a design diameter of 25 mm (see photo # 7; during the survey of the object, the bolts were corroded and their actual diameter is about 19 mm), installed every 92 cm next to rack tower. The number of bolts on the outside is equal to the number of racks and is 52 pcs. The bolts are anchored in a monolithic foundation, they pass through the holes in the support ring and are tightened with nuts. Thus, the lower ends of the steel profiles (posts) are securely attached to the support ring.

During the operation of an architectural structure, the support metal ring has been subject to significant corrosion for 100 years (photo 9-10). Therefore, we recommended to open the support ring, clean it from corrosion, strengthen it (photo 11-12), then apply an anti-corrosion coating on its surface.

Photo 8. General view of a metal gusset, riveted with corners No. 120; by means of a gusset, the posts are riveted to the metal support ring of the tower

Photo 9. Fragment of the joint between the gusset and the tower support ring; the lower part of the gusset is significantly corroded, it is recommended to strengthen such places of the supporting part of the structure (before strengthening)

Photo 10. Fragment of the joint between the gusset and the support ring of the tower during the survey of the object the lower part of the gusset is significantly corroded, it is recommended to strengthen such places of the supporting part of the structure (before strengthening)

Photo 11. Fragment of the joint of the gusset plate with the support ring of the tower

after strengthening (the support ring of the tower is reinforced with metal legs, alternating in the rods in and out)

Photo 12. Fragment of the joint of the gusset plate with the support ring of the tower

after reinforcement (the support ring of the tower is reinforced with metal legs, alternating in the rods in and out)

The outer surface of the tower pillar structure (photo 13) consists of 26 pairs (52 pieces) of equal-sided corners No. 120 (its actual thickness is 16 mm). The actual thickness of the gusset plates in the good parts of the structure is 12 mm.

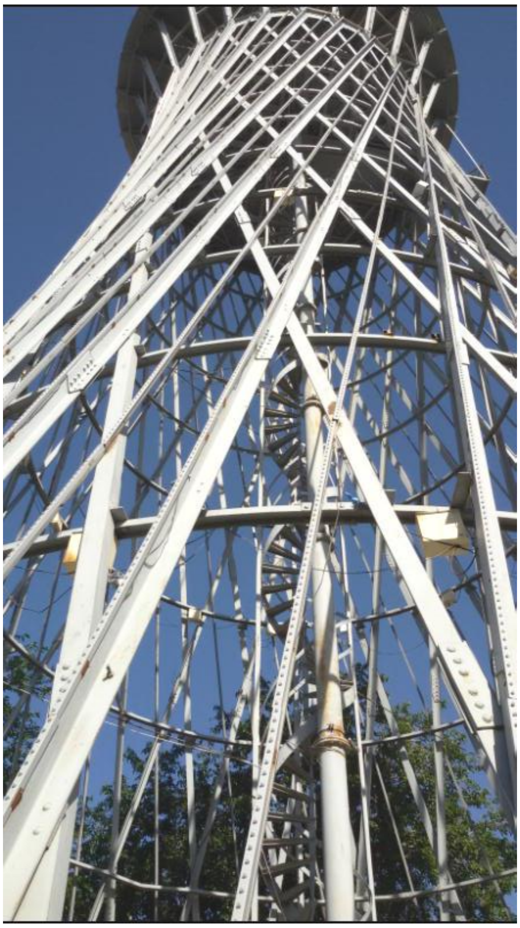


Photo 13. General view of the outer surface of the tower, the racks of which consist of isosceles corners No. 120, interconnected by rivets (gussets are inserted at the points of contact between the coals); a water pipe is installed in the center of the site, and a service ladder is attached to it; significant damage to these elements is not observed

To increase the stability and strength of the structure, a strapping belt (photo 13-15) made of metal channel # 10 is installed along the inner part of the tower in a circle along the height of the structure. The total number of belts is 10 pieces, of which the 1st belt is installed at a height of 2.6 m from the level of the concrete floor, the next belt is installed at a distance of 2.4 cm from the lower belt.

Surveys have shown that in some belts local stability losses (damage in the form of belt curvature) are observed in places. Therefore, we recommended eliminating damage to the belts of the structure, which will be carried out during the reconstruction of the object.

Photo14. A fragment of a circular belt of the 1st tier of a southern orientation, which has lost some stability

Photo 15. General view of the lower platform, rods and round belts, service ladder and tower water pipe; no significant damage is observed in these structures

Analysis of literary sources shows that the towers of the Bukhara type are stable. So, for example, during the retreat in March 1944, the Nazis wanted to blow up such a tower in the town of Pomoshnaya. For this, the explosives were planted symmetrically on both sides. The explosion sounded simultaneously. Eyewitnesses claim that at the same time the tower rose into the air (they say that it was about a meter and seemed to hang for a moment), and then slowly sat down on its partially damaged supports. This proves the good stability of mesh water towers.

In historical terms, it is pertinent to note that in the first half of the 1970s, the Bukhara water supply system was improved. In this regard, the Shukhov tower lost its original function, and for some time it was not used. In the 1990s-2000s, it was decided to use this historical and cultural object. An elevator was installed in the tower. A certain entrepreneur set up a restaurant on the site, below the observation deck (the top of the tower), from where a wonderful view of the old Bukhara opens.

Now the object is planned to be used as a pure observation platform. According to building codes (KMK 2.01.07-96), the standard load per 1 m2 of the observation deck is 4 kPa. The total area of the observation deck is about 65 m2. The standard load on the entire observation deck is about 26 tons. Preliminary calculations have shown that the strength of the tower lace coals is sufficient when the platform is loaded with a standard load. However, there was a problem in the support ring and in the lower gussets of the tower, so the lower part of the tower was reinforced according to our decision.

Thus, based on the examination and analysis of the technical condition of the tower structures, the following conclusions and recommendations can be drawn.

Conclusions and recommendations

1. The technical condition of the foundation of the structure is satisfactory. However, there is no insulation on its side surfaces; it is recommended to open the tower foundation around the perimeter and insulate its outer surfaces.
2. Around the perimeter of the foundation, it is necessary to arrange a blind area 1.5-2 m wide (behind the supporting bottom ring) with a proper slope.
3. The metal support ring of the tower is subject to significant corrosion. It is necessary to clean the ring from traces of corrosion and apply an anti-corrosion coating to it.
4. The lower parts of the vertical metal gussets used to connect the racks with the lace support structure are subject to significant corrosion, in places destroyed; therefore, a solution has been developed and the reinforcement of these structures with additional metal elements has been implemented in practice.
5. The technical condition of the coals serving as lace racks is generally satisfactory.
6. The technical condition of the belts made of channel bars are strongly deformed in places (there is a partial loss of stability); proposed a solution to eliminate damage to the belts.