ANALYSIS OF THE CONSTRUCTION OF A HISTORICAL MONUMENT MINARET KALYAN

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Annotation:

The Kalyan Minaret is a majestic structure, erected at the cathedral mosque of Bukhara during the reign of the Karakhanid Arslan Khan in 1127-1129. The Kalyan Minaret was built during the reign of Karakhanid Arslankhan.

Key words:

Kalyan Minaret, mosque, architect, circles, foundation, radius, diameter, base, height, module, spiral staircase, "lantern", ganch, burnt brick, spiral staircase, natural dimensions, proportions.

The Kalyan Minaret is a majestic structure erected at the cathedral mosque of Bukhara during the reign of the Karakhanid Arslan Khan in 1127-1129. The Kalyan Minaret was built during the reign of Karakhanid Arslankhan. (fig. 1). This Minaret is the tallest building in the city (46.5m), the year of its construction is carved into the engraving of the middle part. The minaret is a round retaining one built of solid gakyil and baked bricks. It has a spiral staircase of 104 steps (Fig. 2). There are 16 windows in the upper part of the cylindrical tower.

From the Minaret sounded a zan. On the adjacent side of the mosque, the Minaret is connected by a brick bridge. Every Friday, 4 moazzins climbed the Minaret and sang the adhan, after which they summoned them to prayer from the remaining 200 minarets.

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The foundation of the minaret is deep (a 13 m pit did not reach the base), the minaret is relatively well preserved. It is widely covered in the scientific literature, but there are no publications on the analysis of the co-dimensions of the structure.

The side of the decahedron of the base of the minaret is 338 cm.The radius of the circumscribed circle

$$R = a (\sqrt{5}-1) /2=338x1.618=546cm \text{ or } 9 \text{ gyaz},$$

taking gyaz equal to 60.6 cm.

The circumference at the base, measured in kind, is 3043 cm, the radius of which is

$$R1 = S / 2\pi = 3043 / 2x3.14 = 484.6 \text{ cm}$$

It is noteworthy that the difference between these radii

$$R-R1 = 546-485 = 61cm$$

i.e. gyazu with small errors. The radius (r) of the circumference of the top of the minaret at the “neck” is 300 cm. It is equal to a large segment when dividing the radius (R1) of the base in the middle and extreme ratio (Fig. 12,): $r = R1 (\sqrt{5}-1) /2=485x0.618=300cm$

This value corresponds to the side of the decagon, inscribed in the circumference of the base of the minaret, and is a module in establishing the height proportions of the structure:

The height of the base is 3 rm.

Height, from the edge of the base to the beginning of the spiral staircase - 2 modules. The height of the "floor" is 2 modules.

The height of the "lantern" is 2 modules.

Central post diameter - 1 module.

However, it should be noted that the height of the “floor” in nature is 288 cm, that is, 12 is less than the module equal to 300 cm. Such an error can only be explained by the fact that the ganch mortar used for laying the minaret was under pressure. laziness is able to thicken. If such a compaction of each seam occurred by 2-3 mm, then to the height of the "floor", that is, by 50 seams, it could be expressed in 10-15 cm of theoretical substantiation and application of the conoid on the soil of Central Asia.

Many publications are devoted to the Vabkent minaret. It was studied in the most detail by V.A.Nielsen. The work provides a detailed description, dimensional drawings, unfortunately, not provided with dimensional indicators: The conoid of the spiral staircase of the Kalyan minaret was designed by the architect Baki and made by craftsmen with great precision, as evidenced by on-site measurements and analyzes. The spiral staircase of the Kalyan minaret is of interest for the history of science - this is the first case. The Vabkent minaret in many ways resembles the Bukhara minaret, but it is smaller and slender than the Kalyan minaret - it has a strong thinning. The minaret has preserved well, while from the mosque of the XII century. standing nearby, no traces remained. The minaret stands alone in a small square at the city's transport crossroads.Observations allow expressing only some considerations about the proportions of this structure.

Only the circumference at the edge of the base was subjected to control measurements. It turned out to be 1945 cm, that is, the diameter is 620 cm (or 10 gyaz, assuming 62 cm gyaz), which coincides with the data of V.A.Nielsen. The base of the minaret is a regular dodecahedron, while the circular gallery of the "lantern" is ten-spanned. Since the architects took the proportionality of the structure from the plan, it can be assumed that in this case the proportionality of the minaret; could be expressed by the derivatives of both a hexagon and a rectangular triangle of the peak with sides 1,2, $\sqrt{5}$, associated with dividing the circle into ten parts.

The diameter of the "lantern" is proportional

$$D\sqrt{3} / 3 = D620\sqrt{3} / 3 = 358 \text{ cm}$$

Natural sizes - 366 cm; error -8 cm.

The height of the plinth is proportional

Fig. 3. Kalyan minaret in Bukhara (1127) .General view

$$D\sqrt{5} / 6 = 620\sqrt{5} / 6 = 231cm$$

Natural dimensions - 230 cm. The height from the base to the "neck" of the minaret is commensurate with six diameters of the base.

From an examination of the proportions of the Bukhara and Vabkent minarets (Fig. 2) as well as the analysis of the proportions of a number of other minarets given in the table, we have established the presence of regularities in the construction of their architectural form. So, for example, the ratio of the areas of the base and the top of the minaret is presented as 2: 1; 4: 1; 5: 1; 5: 3; 4: 3; 2.91: 1; 2.618: 1 and even 25: 1.

Involuntarily the question arises: what geometric constructions did the architects establish such relations of areas?

This question is answered by the information given in the appendix to the book of Abu-l-Waf Buzdjani. About what artisans need from geometric constructions", in the section devoted to approximate calculations

of the areas and ratios of the square of the side of many squares to the square of the diameter of the circumscribed circle.

In the first lines there are four architectural monuments of the XI-XII centuries - the Burana tower, the Uzgen minaret, the minarets in Mesh-hed-i-Misrian and in Jarkurgan. They are different in appearance and proportions; the first of them, built in mud brick, is the most squat, its height is expressed by three diameters of the base; The Jarkurgan minaret is slimmer, its height is measured in six diameters of the base. However, these four minarets have something in common; the areas of their bases relate to the area of the top as 4: 1, which corresponds to the postulate from the treatise for architects, which says: “The ratio of the square of the side of the hexagon to the square of the diameter. The ratio of the areas of the base and top of the minaret in Vabkent is 5: 1. Abu-l-Wafa Buzjani.

The minaret in Mashhad-i-Misrian (XIII century), according to measurements by A. M. Pribytkova, has a round base with a diameter of 8.25 m, and the diameter of the top of the minaret of the circumscribed circle is equal to a quarter. According to A. A. Asanov - 3.0 m. The area of squares of their diameters is 68.06 and 9.0 sq. m are treated as 36: 4.75. It is striking that in a treatise for architects we read: "When the square of the diameter of the circumscribed circle is 36, the square of the side of the hexagon is 4 3/4.

In the architectural ensemble of Gur-Emir, four minarets, which once stood at the four corners of the square courtyard, now do not exist. According to measurements by A.V. Shchusev, the southeastern minaret had a round base with a diameter (D) of 290 cm, and the diameter of the top (d) - 245 cm.With a radius (R) of the base of the minaret, the diameter of the top (d) is $R\sqrt{3}$, therefore V0: VB = 4: 3 It is possible that the architect Muhammad ibn Mahmud used the postulate "The square of the side of an equilateral triangle is so related to the square of the diameter of the circumscribed circle as 3: 4" to determine the proportions of the minaret.

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