

The Diagonal Grid as a Design Method in the Armenian Medieval Architecture

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Abstract—Armenian architecture has been a subject of serious studies since the beginning of last century. Numerous medieval constructions have been measured, researched and reconstructed. However, there is a major disagreement among the specialists on the existence of a design stage, preceding the actual phase of construction. The absence of actual data and survived projects, as well as the limited historical information on this issue, are the reasons of this disagreement. That is why the historical evidence on the activity of Trdat the architect, provided by the 10th century chronicler Asoghik, is of critical importance. In this historical record the chronicler testifies that Trdat had a preliminary idea on the reconstruction of ruined St. Sofia dome. The information provided on Trdat's method is of particular interest, as the latter set an example and prepared a model of the future construction. The Cathedral of Ani was erected by the same architect Trdat in 989. The study of the cathedral's measured materials may shed a light on the issue of existence of preliminary developed drafts with volumetric and spatial solutions of future structures. Here the diagonals drawn by the midpoints of the dome columns are not only the principal lines of the planning, but also a part of a uniform diagonal grid, which underlies the whole plan. The facades fit into a square and all key feature marks are located in horizontal lines, which are set on the peaks of diagonal grid. The slopes of pediment are obtained by connecting the vertices of a smaller grid to each other. The same construction principles were identified as a result of measurement research about Marmashen Cathedral (which was built in the beginning of the 11th century and is attributed to Trdat) and Noravank (this church is considered to be a masterpiece by the architect Momik of the 14th century). The studies have helped to come to the conclusion that the diagonal grid as a design method has been continuously used by Armenian medieval architects throughout centuries.

Keywords—*diagonal grid; design method; church; plan; facade; square*

I. INTRODUCTION

Armenian architecture is an art form of one of the world's ancient peoples, who founded their State long before the advent of Christianity. It features strong traditions preserved and developed over the centuries and it is notable for its unique characteristics: originality, rigor and monumentality. Armenian architecture particularly reached its highest level of development after the adoption of Christianity as the State religion.

Being a subject of serious studies since the beginning of last century numerous medieval constructions have been measured, researched and reconstructed. However, there is a major disagreement among the specialists on the existence of a design stage, preceding the actual phase of construction. The absence of actual data and survived projects, as well as the limited historical information on this issue are the reasons of this disagreement.

Medieval chronicles, when referring to construction of one or another structure, generally approached to the subject from the standpoint of historical events or historical personalities. They would rarely mention the names of architects and would even less cover the activities related to their work. Some chronicles briefly described in their records the processes of construction of a few churches, particularly mentioning that the architects were determining the measures of the future structure by using special cords in place, and cornerstones were laid down and the locations were lit up by priests.

The assumption about the abstract idea of the composition of buildings is based on the above-mentioned information. This means that the architect was managing the construction and calculating the measurements of the structure on the spot, and keeping carrying on the process of the construction was solving different aspects of emerging issues.

Nevertheless, the 10th century chronicler Asoghik provides important historical evidence on the activity of Trdat the architect. In this record he testifies that Trdat had a preliminary idea on the reconstruction of ruined St. Sofia dome, which had been destroyed by an earthquake in 986.

The historian says: "A terrible earthquake has affected the whole Greece. Brilliantly decorated marvelous colons and icons of the royal capital Constantinople's churches collapsed, and St. Sofia itself (the cathedral) cracked from the top to the bottom", and later "Greek skilled architects worked hard to reconstruct it. There was at that time an Armenian masson-architect — Trdat, who set up a project with considerable imagination and prepared the model of the structure. According to this project the construction works were launched and after the restoration the cathedral appearance was even more graceful than before" [1].

The information provided on Trdat's method is of particular interest, as the latter set an example ("plan" or "project") and prepared a model of the future construction. It is assumed that the preparatory works were carried out in two stages: first the project, then the model. The text of chronicle Asoghik illustrates the fact that the project and the model providing unusual architectural solutions played a major role in getting the contract.

This is the only data on the description of preparatory works of the construction in Armenian historical sources.

Models were prepared already in early middle age in Armenia. Architectural theorist Paolo Cuneo exploring the models of Armenian churches classified them into 4 categories: Endowment model, model for the maintenance of relics, Acroter's model and miniature model [2]. The model of the church found in Angeghakot dated from 5th to 6th century belongs to the latter category. The studies have disclosed a clear proportionality of its volumes, which helps to prove that the model was based on a project [3]. This discovery confirms the credibility of Asoghik's records, who claims that besides the model Trdat had also presented a project of reconstruction of St. Sofia to the Byzantine emperor.

II. ANI CATHEDRAL

The same architect Trdat erected the Ani Cathedral, which has almost entirely preserved up to the drum mark. The study of measurements can shed a light on the possible existence of preliminary design project with its space planning decisions elaborated by architect before the construction.

In the relation to three-dimensional space the cathedral is a rectangular prism in the plan, which in the upper part becomes cruciform. It is covered by gable roofs, in the centre of which the cone-shape drummed dome was raising.

The plan of the cathedral reminds the type of a three-nave domed basilica, which in Armenian religious architecture was developed in the 7th century (Bagavan, Gayane, Mren)

The canonicity of the rectangular ground plan cathedral (21.78x34.29) is perceived at first sight: three entrances of the church are adjusted on the axes, which are localized in the center of the composition. Equidistant dome pylons fit into squares that are turned to the façades by 45 degrees.

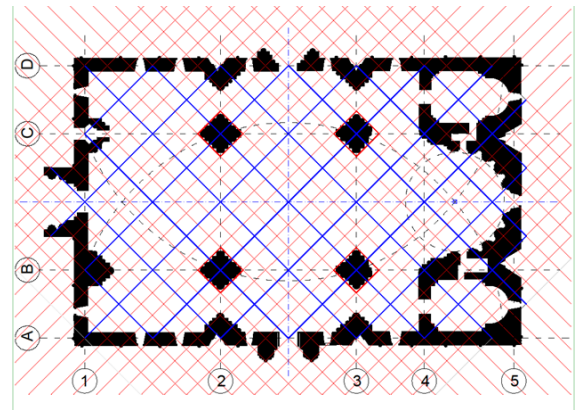


Fig. 1. Regular grid underlying the plan of Ani Cathedral.

Abovementioned observations assume that the architect chose the projection of dome's centre as an initial point of planning. The midpoints of the dome columns are located on perpendicular 45-degree angle lines, which intersect at the initial point of the construction. The match of intersection points of mutual perpendicular 45-degree angled lines with the featured lines of constructions can be detected at a rather early stage. Consequently, it should be considered that we deal with a deliberate system based on regularities.

This system complies also with the necessary functional organization of interior space from the religious point of view. It consists of functionally separated parts: the prayer area, the altar, and 2 adjacent chapels.

The planning of any architectural structure needs to be launched with the construction axes determination. The vertical and horizontal axes were drawn and the spaces between the columns were detected in the relation to the dome span conceived in advance.

The interior space of the church in the North and South is limited by horizontal construction lines and intersection points of constructive lines, which are established in relation to the midpoint of dome pylons at 45 degrees. In the western part the interior space adjacent to under dome square has the same size as the latter. In the East — the prayer area is limited by the half span of the under dome columns.

In the plan the horizontal and vertical lines limiting the interior space of the church pass through the interior walls. Actually these lines are the constructive axes of the structure.

The center of the altar semicircle is located at the intersection point of symmetric arcs, which are passing through the midpoints of the pylons. The centers of these arcs are located in the south and north peaks of the central rotated square.

Obviously, here the diagonals passing over the midpoints of the dome columns are not only the principal lines of the planning, but also a part of a uniform diagonal grid, which underlies the whole plan.

The side of the rotated square, which itself fits into under dome square is divided into 6 equal parts by the grid. The grid pitch is 1232 mm, one fourth of which (308mm)

corresponds to half or byzantine-armenian foot [4]. The main lines of the construction have a 3-pitch interval between them, and the pylons fit into rhombuses. The sides of these rhombuses are equal to 2 pitches (see "Fig. 1").

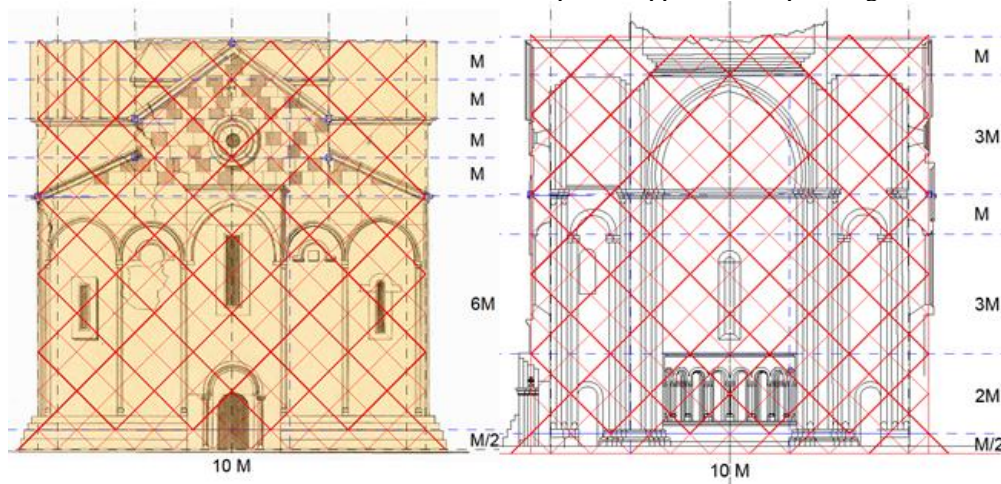


Fig. 2. West façade and the cross-section cut of Ani Cathedral.

On facades all key feature marks are located on horizontal lines, which are set on the vertices of the diagonal grid. The slopes of pediment are obtained by connecting the smaller grid vertices to each other ("Fig. 2").

The fact that a square was used in the plan and in facades can be explained not only as a planning method, but also because the square had a symbolic significance in the medieval Christian worldview. The square is the symbol of equilibrium and equitability, resilience and stability, protection and restriction. In the East the square with tops orientated to the four corners of the world was the symbol of the Earth.

III. MARMASHEN CATHEDRAL

The studies the measurements of Marmashen Cathedral (which was built in the 11th century and is attributed to Trdat) contribute in addressing this matter. The church has domed hall composition, which was already developed in early centuries. This composition type gradually evolved and eventually acquired canonic architectural forms and features. It achieved its zenith in Marmashen church, where the domed hall has turned into a centric structure with absolutely symmetric facades.

The similarity between the lower levels of Marmashen and actually larger Ani Cathedral is complemented by the recurring correlation of external dimensions in the plan. At Marmashen the ratio of cross-section and longitudinal dimensions is about 0.658 (12, 62m: 20m), at Ani Cathedral -0,638 (21,87m: 34,29m).

The regular grid turned at 45 degrees to 4 corners of the word and underlying the plan of Ani cathedral matches to the one in Marmashen. The side of rotated square located between the inside surfaces of longitudinal walls is composed of 6 cells. The side of the square located between

The studies of cathedral's preserved dimensions indicate that the cross-sectioned sizes are repeated also vertically. As a result, the cross-section cuts and facades fit into a square, which is actually a logical continuation of the consistent pattern applied in the planning.

external surfaces is made of 7 and the altar diameter of 3 cells. The interval between inside surfaces of transverse walls is equal to 10 cells. The interval between external surfaces is of 11 cells. The axes of the walls also follow the structure of the same grid and are located on the tops of cells which are twice smaller.

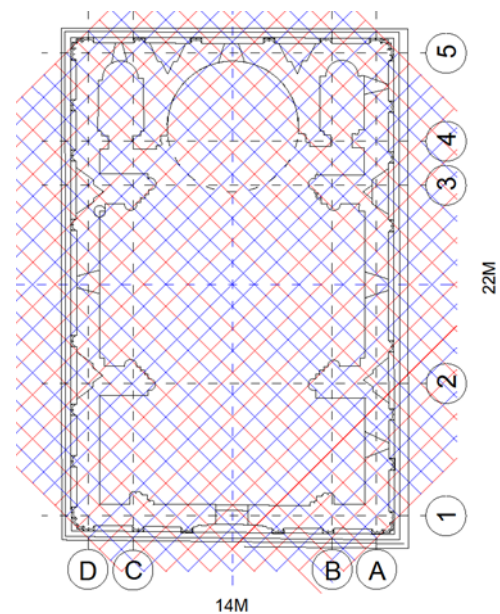


Fig. 3. Regular grid underlying the plan of the Marmashen Cathedral.

The distance between the centers of pylons and the center of the composition is equal to 9 cells of the small grid (as can be seen in "Fig. 3").

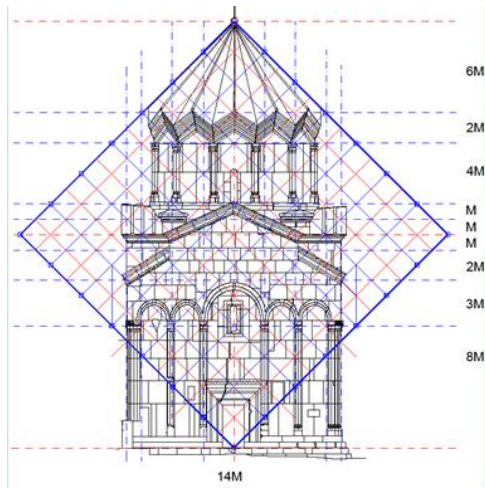


Fig. 4. The western facade of the Marmashen Cathedral.

On the facades we see the same grid with scaled pitch, where each cell contains 4 small cells. The side of the rotated square, which is exteriorized on the facade of the church, is divided into 7 parts by this grid. The horizontal diagonal of this square goes through the upper edge of the roof's fronton horizontal eaves. The upper part of rotated square, which matches with umbrella dome, occupies three cells. Not only the contour lines of the church's main dimensions match with the lines of the grid, but also all feature lines of secondary dimensions, details and decors go through the knots of the grid. (as can be seen in "Fig. 4")

The subject on the application of diagonal grid is discussed in the article authored by A Yeremyan, which was dedicated to the planning basics of domed constructions from 5th -7th centuries. By studying the measurements of several churches she identified this method. [5]

IV. NORAVANK CHURCH

Further application of diagonal grid as a planning method in Armenian architecture is proved by analysis of measurement of the 2-floor church Noravank. This is a masterpiece of a master architect of 14th century, named Momik.

This church acquired its present appearance in the end of last century. Before the restoration

It was preserved up to the level of two floors and the rotunda had entirely collapsed. We have analyzed the measured dimensions. The ratio between the sides of the rectangular planned church is about 2/3. In the plan, in the sections and on the facades a grid with the same pitch is used. However, while in the interior space the intersectional lines of surfaces mostly match with the knots of the smaller grid, on the facades they match with the knots of bigger grid. Furthermore, one cell of the enlarged grid on the longitudinal facades consists of 3 small cells and of 2 on the transversal facades.

The longitudinal facade fits into a square. The upper corner of rotated square, which also fits into the square,

matches with the facade's fronton. The section points of the bigger square's diagonal along with the upper sides of the rotated square match with the bottom mark of the fronton, and the line passing through these points matches with the upper edge of the roof's horizontal eaves.

The contour lines of all main dimensions of the longitudinal facade go through the knots of the grid whose pitch is equal to 1/8 of the rotated square's side. Thus, the upper edge of the ground floor eaves goes through the upper point of the third cell if considering from the ground zero, and the upper edge of eaves aisles goes through the top of the 5th cell.

On the western transversal facade the whole first floor of the church fits into a square. The rotated square which fits into this square also matches with the frontons. The height of the ground floor is equal to half of the rotated square's diagonal.

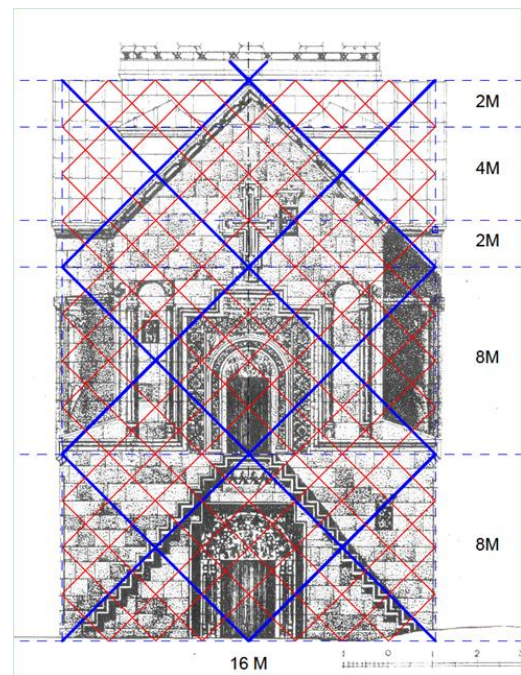


Fig. 5. The western facade of the Noravank church.

The contours of the eaves on the transversal facade also go through the peaks of the diagonal grid. The width of the door openings is equal to 1 rotated cell, and the height is equal to 1.5. The decorative elements also mostly match with the grid (shown in "Fig. 5").

V. CONCLUSION

The studies have helped to come to the conclusion that the diagonal grid as a design method has been continuously used by Armenian medieval architects throughout centuries.

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