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The Manifestation of Geometric Principles in the Traditional Architecture of the Monasteries; Case Study: Sheikh Shahab Al-Din Ahari Tomb and its Hidden Geometry

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ABSTRACT: The tomb of Sheikh Shahab al-Din Ahari was built in the 6th century AH and its evolution has taken place in the periods of the Ilkhani, Timurid, Safavid periods. Sheikh Shahab al-Din Ahari was the master of Sheikh Safi al-Din Ardebili (the Safavid's father). Because of the Safavids, they had a special respect for him, And there are manuscripts around the walls of the mosque of Sheikh Bahai, Shah Abbas III, Abolghasem Nabati, which shows the significance of this monastery during the Safavid period and before it. The unique features of the architecture suggest that the architect used the construction of geometric principles and the exact system of Iranian proportions. And considering that the study of the geometry of the Sheikh Shahab al-Din Ahari monastery, the tomb since the Ilkhanid era in East Azerbaijan, has not been carried out and because of the lack of clear exploratory resources some researches required considering the importance of the subject, geometric proportional analysis approach that seek to answer this question: which role geometry has played in the construction and development of the spatial elements of the monastery? Therefore, the study of analytical research and data collection tool to collect data and information have been used both field observations and library, and in order to revisit the geometric principles and proportions in this collection, geometrical analysis was carried out using geometric analysis, plan, facade and sectional analysis. The results of the analysis indicated that the architect of the building has had the required knowledge of the geometrical proportions and geometry systems that has used theme in selecting the scale of the construction and location of the main spaces, such as: large space under the dome (known as Ghosh khaneh), Chinese houses (Chinikhaneh), courtyard, Eyvan (porch) with two minarets and two small booth of two sides of the floor. The unveiling of hidden geometry in the design of the building reminds us of the privileged position of geometry in traditional architectural design, which helps to better understand traditional architecture.

Keywords: Sacred, Geometry, Iranian, Architecture, Structural, Design.

INTRODUCTION

The past Iranian architecture always has been inspired by the use of geometry and accurate drawing methods, to the extent that knowledge of the rules of mathematics and the drawing and use of particular types of it was the duty of any architecture. The distinction between architects and their competition with each other was based on this basis. Therefore, it is concluded that the geometry of Iranian colonialism is important and the understanding of this feature in contemporary architecture and the relevance of the contemporary and tradition architecture are important and it is necessary (Bowdzhani, 1990; Haji Ghasemi, 1995; Molavi, 2002). The authors with the knowledge of the importance of geometry in the traditional architecture began with this hypothesis that the design of this work could not be formed without the use of geometry. At the first, because of the importance of the Sheikh Shahab el-Din Ahari monastery (Pouraminian et al., 2014), and then the importance of traditional architecture geometry that was one of the most significant sciences that constituted the statue of architecture and most designers used geometric drawings as a scientific basis for their designs, because from the originality of traditional view, they have real aspects of eternity.

Eternity is achieved by means of communication with a major goal through the world of eternal patterns and following the rules of variety of traditional arts. An artist who works within the tradition depicts his soul on the outer world, and with this hypothesis, the writers began to find hidden geometric relationships in this work, and eventually with a great deal of effort they managed to draw some geometrical relations in the design of the building that it can be expected the designer of the building also used such drawings to design this building.

Geometry or proportional geometry is a sacred art form due to its fundamental association with the Creation's principal laws. The visual expression of the order of these laws is best represented through the discipline of geometry. Geometry is both quantitative and qualitative in nature. Its quantitative dimension regulates the order and construction of design forms. Its qualitative nature sets the proportions of design forms and represents an expression of the order of the universe as a visual representation of the truth. Each figure or geometric shape, when seen from the perspective of its symbolic meaning, represents an echo of unity and a reflection of the values and principles within the larger frame beyond that unity (universal unity) (Ardalan and Bakhtiar, 2000). Seyyid Hossein Nasr (2004) argued that geometry and rhythm manifest a doctrine of unity which is central to Islam, upon which Islamic art developed based on mathematical ratios and proportions which represent the very heart of Islam (Kritchlow, 1976).

Geometry is the blueprint of the creation and the generator of all forms. It is a science that deals with numbers in space on four basic levels: the first one is arithmetic (pure numbers), i.e., any measurement or proportion is a geometrical measurement. The second level is numbers in space which represent proportional geometry. They reflect the meanings and "Ideas". The third level is numbers in time, which is the foundation of music. The fourth level is numbers in space and time which represent the cosmology of the universe. Geometry explores and explains the patterns that unify and reveal the structure of the Creation within all natural patterns of growth or movement and their conformity with geometric shapes. All life forms emerge out of timeless geometric codes. Viewing and contemplating these codes allow us to understand the wisdom of the inner workings of the universe in order to fully comprehend and appreciate its beauty based on the concept of proportions. Ikhwan Al-Safa wrote, "One of our aims… consists of demonstrating clearly that the whole world is composed in conformity with arithmetical, geometrical, and musical relations. There, we have explained in detail the reality of universal harmony" (Nasr, 2004).

In the presented paper, the authors attempt to clarify the formation of building form and plan with the help of geometric analysis. The universe was made to be the same as the unseen universe, and everything that has been made in this universe is a symbol of something in that world.

MATERIALS AND METHODS

The authors have used analytical method and information gathering tool in the field of observation and library use. Drawings in this research have been done through the architecture software, AutoCAD. The compilation of the materials in the theoretical discussions and the introduction of geometry and proportions from published researches on Islamic thought, such as the interpretation of the Holy Quran and the books of Muslim scholars. Geometric shapes drawings are based on the study and use of the book: Iranian geometry from Abu al-Wafa Bowdzhani (1990) and the treatise of Moftah al-Hasab from Ghiasoddin Kashani. Pictures and drawings of the building are provided by the authors. Then with considering the structure of the collection in different periods, and the importance of Ivan and Gonbadkhaneh, these two architectural elements have been introduced as the focal points of the building. And by assuming these points for geometric drawings, In order to achieve the geometry of the facade and the architectural plans for the geometrical review was carried out to identify the proportions set, and appropriate and acceptable responses that provided a clear and coordinated process.

Main elements of architecture and affiliated arts

Geometry plays a fundamental role in design of Iranian architectural monuments. From the viewpoint of exterior functioning, the use of geometry as art for creation of shapes, patterns and proportions reminds the Great Architecture of the World and recalls the Archetypes. From the viewpoint of interior functioning, geometry as science for selection of structural dimensions such as height, length and width of the building and its structural elements governs the structural behaviour of the building, the behaviour that follows the geometry. The right geometry makes the building behave correctly.

In order to create harmony and create reasonable proportions in the building, the index or source was determined and all dimensions were subjected to it. Peyman has been such an indicator in Iranian architecture and modular architecture in European architecture. In this architecture, Peyman focuses on living and space spaces, a tool for adjusting dimensions and sizes, and the geometry of the architectural guideline in providing discipline and harmony (Omranipour 2005, 27). The third element in architecture is a form. Pythagoras and his followers believed there is a relationship between numbers and forms. Islamic philosophers like the Muslim Brotherhood also believed in the emergence of the universe based on numbers. In their opinion, the intrinsic basis of this universe is the number, and therefore the number that in fact should be considered as pure quantity. But in this thinking, the meaning of the number is not the values used to measure physical quantities (Leveler, 1987, 20).

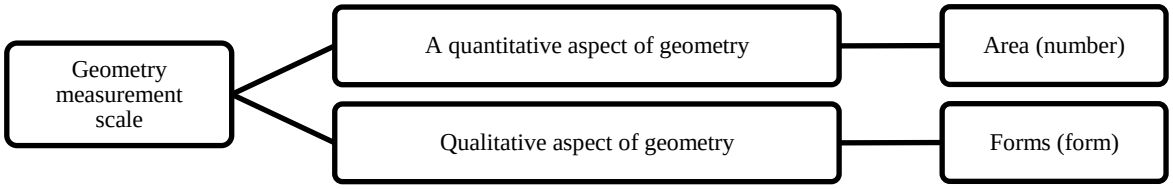


Chart 1. Derivatives from Guenon, 1361, pp. 38-45

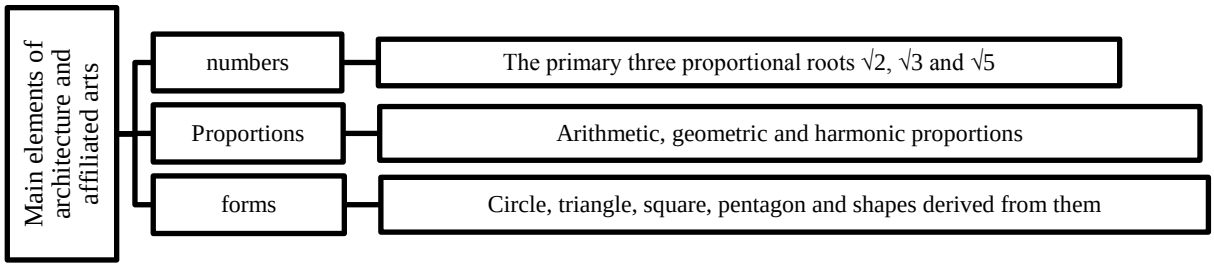
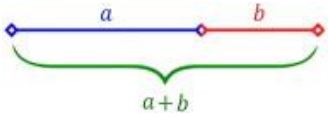
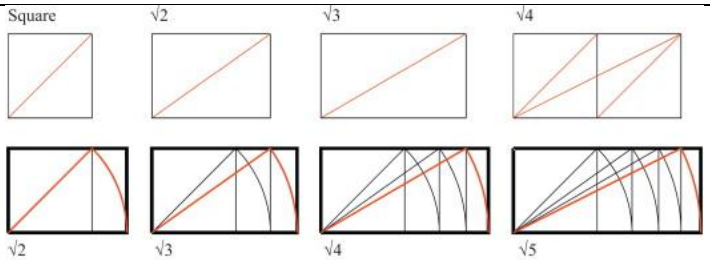
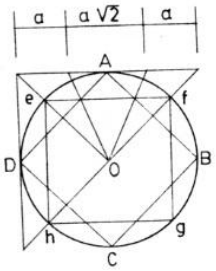


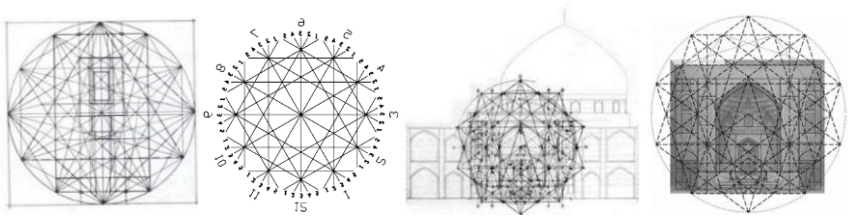
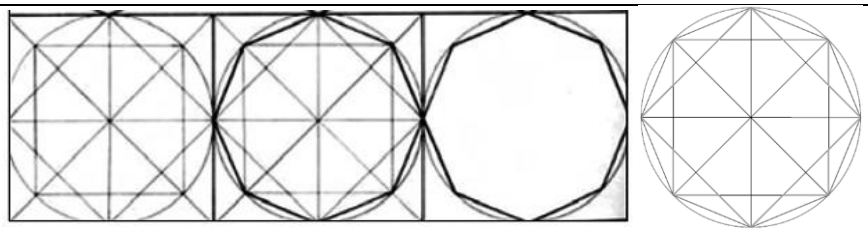
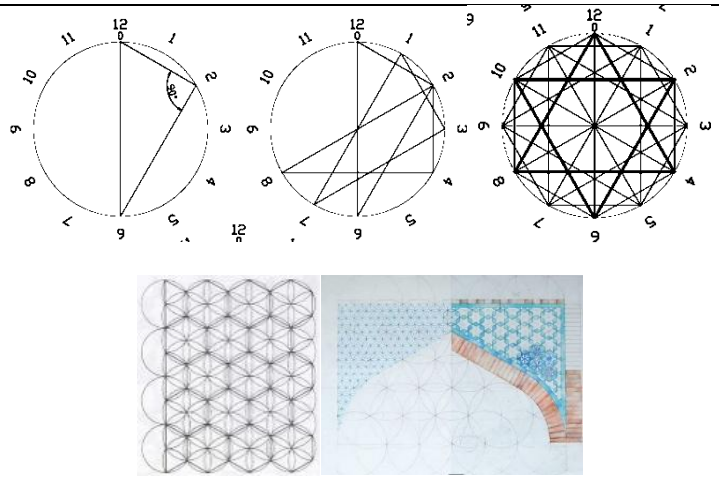
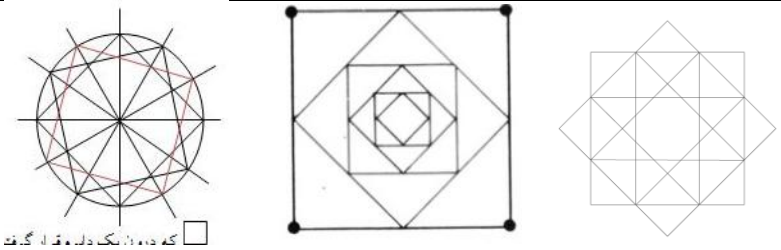
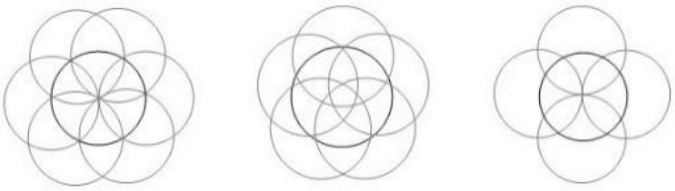
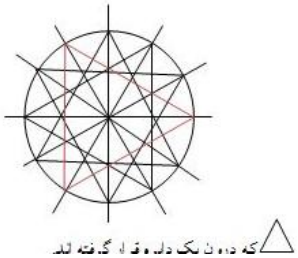
Chart 2. Main elements of architecture and related arts (Tahabaz, 2004)

Geometric proportional systems

In architecture dating back to prehistory, particularly in Islamic arts and architecture, the most important geometric proportional systems are: the proportions of the golden mean and the primary three proportional roots √2, √3 and √5, on which all Islamic arts and architectural forms, especially their geometric pattern design, are based.

Table 1. Some geometric principles used in the architecture of the monasteries (authors)

The main elements of geometry in architecture	component	Description with an example	The geometric order used in the building
Proportions	Golden proportions	The golden mean proportion is a proportional system whereby two elements are related to each other by a set proportion. Two segments of a line not equal to each other are related in a proportion: a/b=(a+b)/a (Figure 1). It is this unique point that divides the single line into segments with qualitative proportions. It is a reflection of multiplicity within unity in terms of geometry. If the line is divided into equal halves, the two segments would be a monotonous repetition of one and the same thing, neither multiplicity nor unity within the geometry.  **Figure 1.** The golden mean proportion: a/b=(a+b)/A=1.61803.	
	The root proportions based on the square.	 **Figure 2.** The successive constructions of the root proportions in proportional rectangles based on the diagonal of the square.	The geometric order of plan and facade
	The ratio of the lateral side to the radial side is 2	 **Figure 3.**	The geometric order of the facade

Special numbers	Twelve	 **Figure 4.** Geometry analysis of the View of the Sheikh Lotfollah Mosque in Isfahan (Haji Ghasemi, 1995)	Geometric order and decoration
	Eight	 **Figure 5.** In the above drawing, we divide the circle into eight equal parts. If we connect these points to the adjoining points, we will surely have a regular octagon. Now, if we connect points, two to two, four to four, and six to six, then two nested squares are obtained. The resulting octagon is related to Islamic architecture and arts.	The geometric order of plan and facade
	Six	 **Figure 6.**	Geometric order of facade and decoration
forms	Square	 Which are inside a circle **Figure 7.**	The geometric order of plan and facade
	The circle	 **Figure 8.** The geometries examined above include circular geometry.	The geometric order of plan and façade and decoration
	Triangle	 **Figure 9.** The geometries examined above are triangular geometry.	The geometric order of plan and facade

Geometry Analysis at Sheikh Shahab al-Din Ahari Monastery

Using geometry in design can be considered from two perspectives: 1. Finding important points and places in a way using geometric drawings, which is the main theme of the analysis in this article. These drawings can be studied in two levels in general. The first level involves the appearance of geometric shapes along the way. Like squares, octagons and regular polygons visible in plan, facade and detail. The second level analyzes geometric designs that determine the dimensions, direction and comonomy of previous levels, and are not at first sight.

Using geometric drawings to obtain the values and proportions that determine the dimensions and proportions of the organs of the structure and its components, as seen in Egyptian and Greek architectural works. These drawings generally result in numerical results such as √3, √2, golden ratio, etc., and then these numerical ratios appear in dimensional forms. In this paper, we will look at this type of analysis as a sub-topic.

Documents for hidden geometric order, at the first is performed on a three-dimensional model with considering the plan, view and cross-section simultaneously. The use of AutoCAD software eliminates the need for maps with variety of scales and increases the accuracy of the drawings.

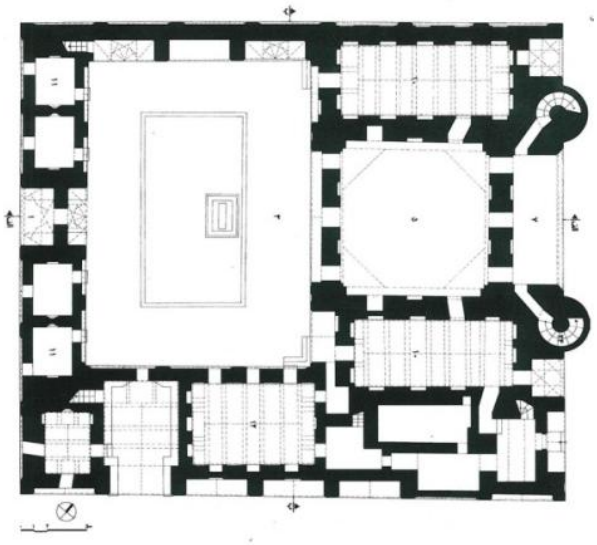


Figure 10. The Monastery Plan, Source: East Azerbaijan Cultural Heritage Organization

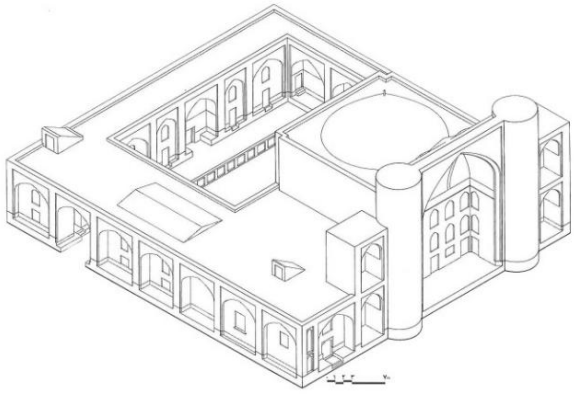


Figure 11. 3D vision, Source: East Azerbaijan Cultural Heritage Organization

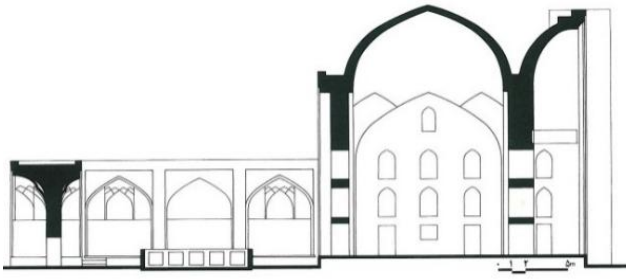


Figure 12. Vertical section A-A Source: East Azerbaijan Cultural Heritage Organization

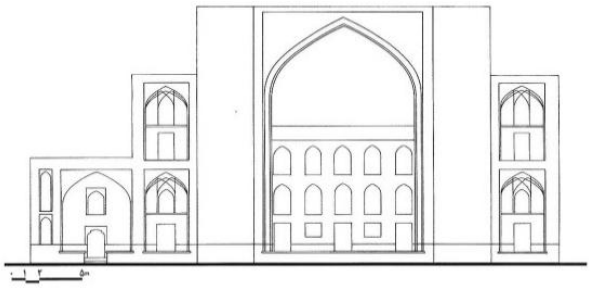
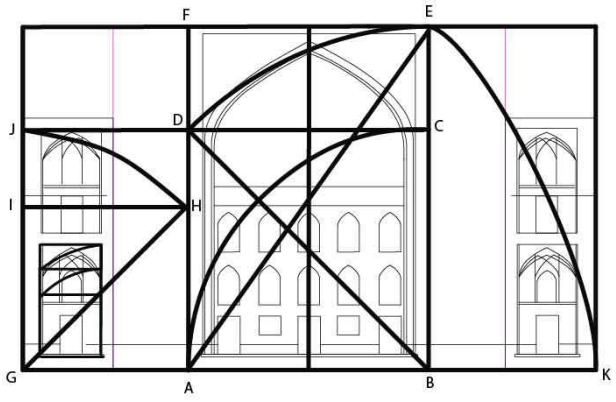


Figure 13. North View, Source: East Azerbaijan Cultural Heritage Organization

Geometry in the facade

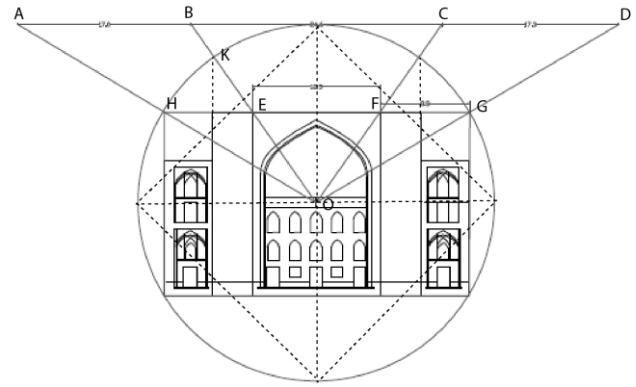
The first form that attracts the attention is the golden ratio. The length of the ABCD square is approximately the width of the main porch and the other side of the square (BC-AD) to the vertex curve. By drawing the DE curve into a square diameter radius (BD), we see the golden proportions on the front of the main monument of the tomb, also by drawing the EK arc in the ABEF rectangular radius, the proportions of the end point of the main view K are obtained and, similarly, these proportions are visible in the small stands of the two floors of the faces of the GADJ and in the exterior of the Booths.



Draw 1. Golden proportions in the main facade of the monastery (North) Source: authors

Referring to the radical proportions 2 in the table, taking into account the middle of the inscription of the porch (O) and drawing the peripheral circle and connecting O to E and F, the line segment BC becomes radical 2 times the segment AB and CD of the connection The point O is obtained at the H point (the end of the

line). Also, from the intersection of the OB line with the peripheral circle, the point K is obtained, which specifies the edge of the minaret.

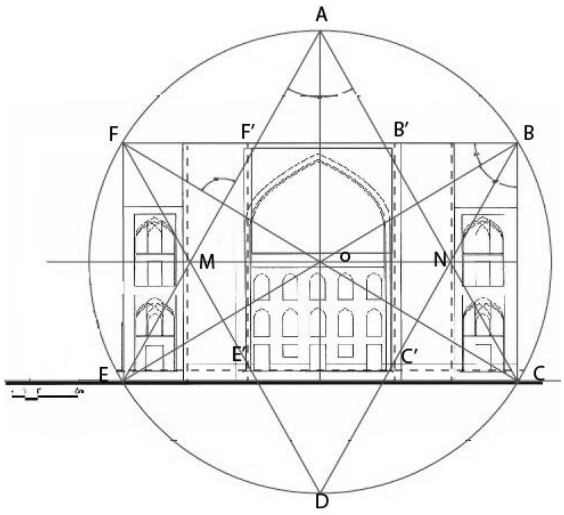


Draw 2. Eyvan ratio to side frames is Radical 2. Source: authors

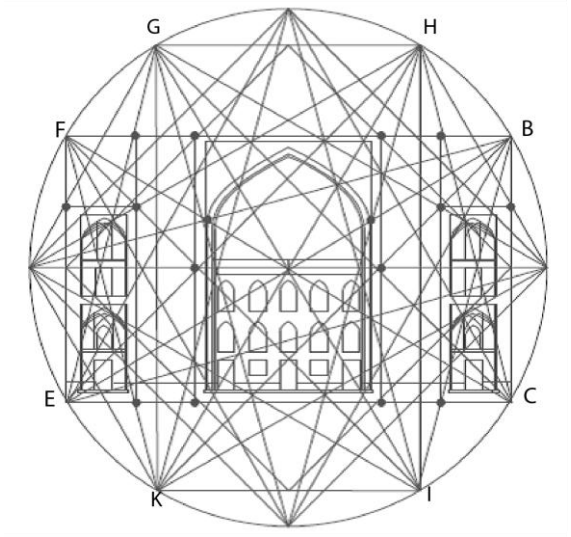
Preliminary drawings are required before the other key points are obtained. The first is drawing the equilateral triangle which represents the regular size of the facade, including the sides of the sides AB, BC, CT.

And then draw the triangles equilateral triangle by drawing the FBD Shamse we have six hexagon ABCDEF environment FBCE rectangle like the picture. The vertex O corresponds to this hexagonal on the Avon inscription center. It is very common to draw a six-slice with this orientation in traditional Iranian architecture. For example, the 6-point basis for finding the optimum Ron (Pirnia, 2008, 136) is also a hexagonal base for drawing the Iranian golden rectangle (1): √3 And the intersection of AC and BD on minarets along the center line and the intersection of M and N coincide is an AC, DF, AE, DB with rectangular FBCE, rectangular porch environment F'B'C'E 'achieved.

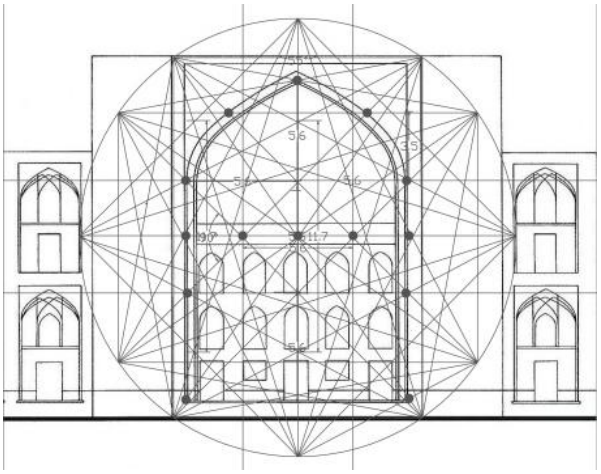
We obtain the GHIK rectangle from the 90 degrees rotation of FBCE rectangle and the intersection of the sides reveals the main points of the view. Refer to the method shown above for the entire view, by extending the 12-edge geometry on the porch, appear the main points of the vault and the inscription.



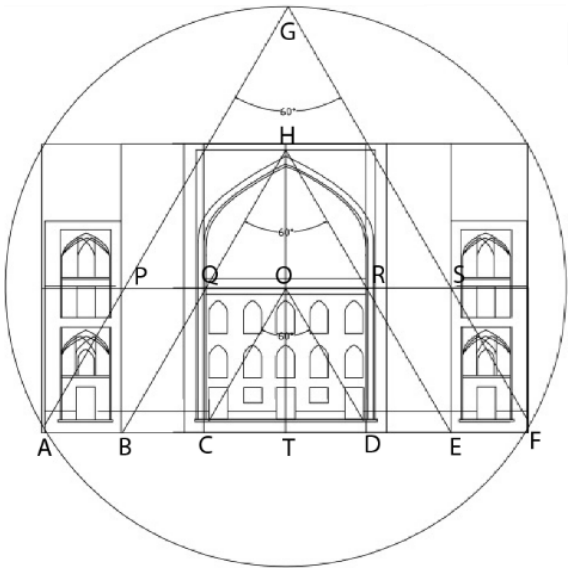
Draw 3.



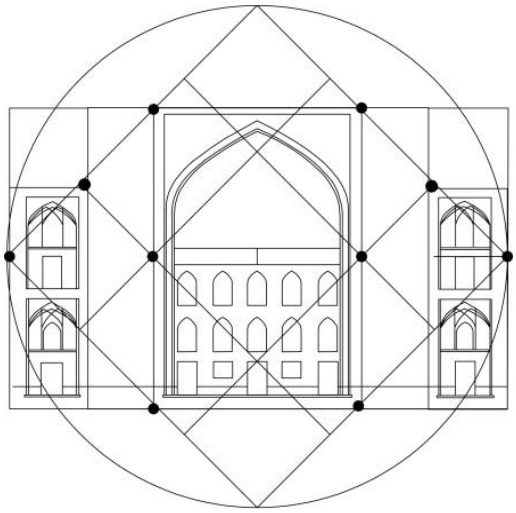
Draw 4. The geometric analysis of the monastery facade has proportional proportions resulting from the division of the circle of the circumference of the face into 12 parts, Source: authors



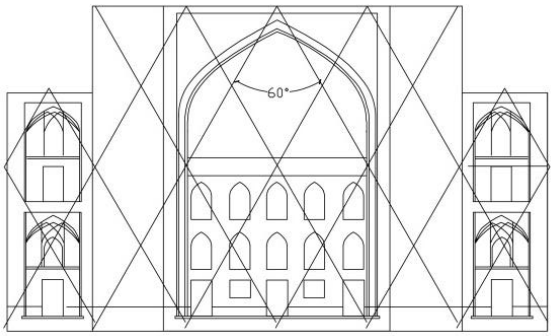
Draw 5. Eyvan (porch) geometric analysis monastery proportional ratios divided by the circle into 12 parts, Source: authors



Draw 6. Geometric analysis with respect to triangulation. Source: authors



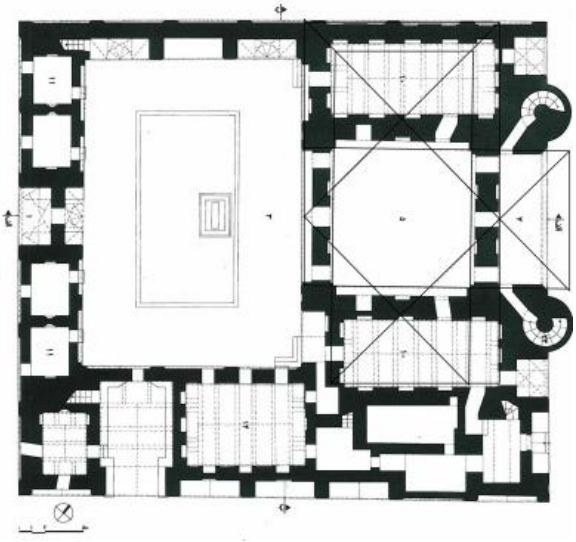
Draw 7. The proportional ratios obtained by dividing the circle into 8 parts, Source: authors



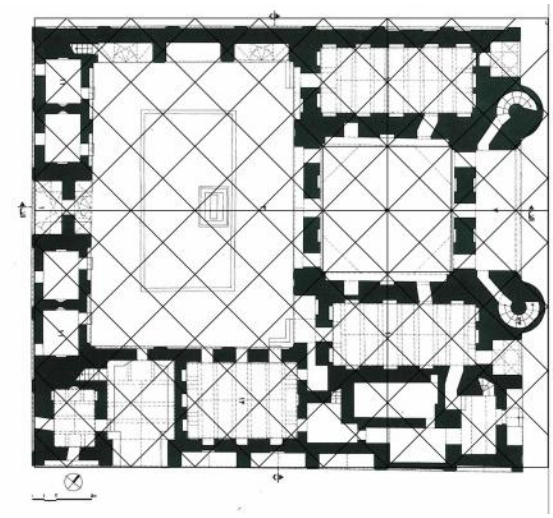
Draw 8. Geometric analysis of faces with respect to triangulation, Source: authors

Geometry on the plan

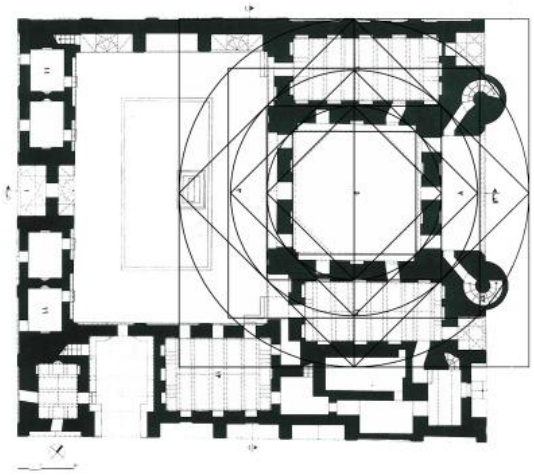
The geometry of the golden proportions in the plan was based on the drawing of the square to the center of the large mosque ABCD and the drawing of the CG arrow to the square diameters (AC), the proportions of the main porch (rectangular BGHC) and the Chinese houses around the Grand Mosque (DCEF). Similarly, golden proportions can be deduced from the yard of the JIFL, the MNOP small mosque and the courtyard booths.



Draw 9. Geometric analyzes with respect to symmetry Source: authors



Draw 10. Geometric analyzes with respect to triangulation Source: authors



Draw 11. Geometric analysis of the facade with respect to the regular octagon Source: authors

Geometry of decorations

One of the specialties of the Sheikh Shahab al-Din Ahari monastery is: On the sides of the eastern side, two flowers are carved into a gray stone piece. Two flowers consisting of "two parallel triangles" and a pyramidal circle that also corresponds to geometry in the main facade of the tomb.

Figure 14. The eastern side of the Sheikh Shahab al-Din Ahari tomb Source: authors

Figure 15. Sample of hexagram of the eastern door in the Sheikh Shahab al-Din tomb, Source: Authors

Figure 16. Decorative sample in Sheikh Shahab al-Din tomb, Source: authors

Figure 17. Sample of sign on the Tombstone in the Sheikh Shahab al-Din tomb, Source: Authors

Figure 18. Sample of sign on the Tombstone in the Sheikh Shahab al-Din tomb, Source: Authors

Figure 19. sample of sign on the Tombstone in the Sheikh Shahab al-Din tomb, Source: Authors

RESULTS AND DISCUSSION

The point in the Sheikh Shahab al-Din Ahari monastery and the monuments of the period and the subsequent periods is the significance of the sixth figure in the proportions and decorations that are clearly visible on the tombstones in the museum's decoration of a hexagram or a six-star filled in the eastern entrance door.

The same figure is on the sides of the entrance to the tomb of “Sheikh Heydar Meshkin shahr” related to the period of 7th and 8th AH and on the tombstones of the “haft tanane Kalkhouran”, in the courtyard of the Sarabi Mosque, most of which are monuments such as graves and tombstones, and the mosque and tomb to "Advar Ilkhani "is attributed. In addition, the Hexagram or six stars has an old role in the architecture of the Mogul and Ilkhan. The coins of the Ilkhan period are of particular importance to researchers in terms of the variety of content and patterns of information they bring.

The coins of the Ilkhan period are of particular importance to researchers in terms of the variety of content and patterns of information they bring. Coins are an important part of archeological documents and evidence for the clear gray aspects of the history and civilization of the ancient nations and peoples. Since the content of the coins has since been devised to reflect the culture, art and religion, social and political relations, the

economic situation, the language and the customs, the customs and cultural geography of different lands and the precise and undeniable sources of periods of human history and culture. That evidence show the presence of the star of David in the center of coins, the doorway to the monasteries and in decorations, shows the support of Jewish religion towards Islam during this period.

The current study aimed to find out the geometry of Sheikh Shahab al-din Ahari Monastery by its designer. The aim was to readout geometry and the proportions of the main facade (the north facade) and the architectural plan and decorations. The result showed that the architect has had knowledge about the systems of alignment and geometric drawings, since in finding the architectural elements in the plan, the layout of the architectural elements in the plan, the fit between the architectural spaces and the creation of decorations on the basis of principles Geometric and excellent proportions.

Considering the evolution of the monastery in different periods, in the architectural dimension, it is closely related to the proportions and geometry of the plan in the eastern part, where the tomb plan is perfectly symmetrical in the northern axis of the south. And the most striking architectural feature of the extension of the patriarch can be found in these cases are: to adopt a kind of space commitment in merging new and initial segments with the application of pre-considered geometric principles, observance of the fit between the dimensions of the spaces according to the principles of standing together with the fit between the spaces and considering the performance of these spaces to meet the physical and mental needs of its users, and on the other hand, with regard to the arrays in the courtyard, workstations on the west side of the courtyard, which are completely different from the east side of the east side, make it possible to attribute the original body of the tomb to this section.

Therefore, with regard to the architectural extension of the building and the recognition of the main elements of this architecture, we have chosen the focal points as the default for achieving the structural geometry of the building, and the regular twelve-dimensional geometric, octagonal and golden proportions in the drawings process are reasonable and fitted to the resulting, and then aligned with the view of the building. In recognition of the geometric shapes of the building, a regular twelve-dimensional, straight-edged octagon, hexagonal, triangulation and the use of accurate golden proportions in plan and facade are praised, and golden proportions and Iranian proportions in evolution have become well melded together; Of course, the existence of proportions in a traditional architectural structure is a proven and inseparable principle of architecture, but the recognition of geometry in both a traditional and new architecture is an analytical work, because it takes us to the idea of shaping which is chosen by the architect. On the other hand, this recognition will help in the reconstruction and maintenance of the work of architecture. Readout and analyzing geometric proportions is one of the most important and fundamental issues of traditional architectural research, which is less archeologically considered, and for the creation of works that are the true continuation of valuable architectural paths, the first step is to get proper and adequate knowledge of it and its type of architecture.

In recognition of the geometry of the building, a regular twelve-dimensional, regular, octagonal, hexagonal, triangular, and accurate golden proportions in plan and facade are praised and golden proportions and Iranian proportions are in perfect development with each other that have been merged.

DECLARATION

Authors' Contributions

All authors contributed equally to this work.

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