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Examining the Proportion in Ma'qeli Decorations of "Khargerd Ghiasieh" School

Abstract

Problem Definition: The study of the proportion in the components of brick decorations in architectural facades (khavun-chini) shows that this proportion results from the ratio of the dimensions of the components to the base-brick, which is created by cutting it to the correct proportions. Regarding the Ma'qeli decoration, which is also based on the pre-designed brick bonding and despite the many research studies conducted on its types, it is necessary to investigate how to balance the brick components and the base-area in which they are used. Accordingly, the problem of this research is to reveal the ratio between the components in a Ma'qeli decoration and the proportion of these components with the base-area in which they are placed. The decorations studied in this research are Ma'qeli works with inscriptions in the «Khargerd Ghiasieh» school made by Qavam al-Din Shirazi.

Objective: this research investigates the quantitative proportions in the decorative elements of Khargerd Ghiasieh School (resulted from numerical calculations).

Research Method: This research is based on data description and analysis in terms of its fundamental purpose and method. The data were obtained through two library-based and field methods. In the field study, Ma'qeli decorations (with inscriptions) have been quantitatively calculated. The decorations studied have been redesigned by computer software.

Results: The results show that, besides the components of the bricks that make up the Ma'qeli, there is also a harmony between the bricks and the base-area that decorates it. These proportions are created because of using a (Peymoon) which is obtained from the traditional measurement unit (Gaz), based on the divisions obtained from geometric drawings, and creates the necessary proportions with very high precision in all the elements and components of the building.

Keywords

Brick, Ma'qeli Script, Proportions, Timurid Decorations, Khargerd Ghiasieh School

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58

Introduction

In the Timurid era, despite the flourishing appearance of tiling and plaster-moulding, brick kept its share in decorations as before. Brick decorations in Timurid buildings got more effect with the help of glaze. The Khofte-Raste arrangement, which was generally used until now, was used with various types of glazed bricks in a Ma'qeli style. This beautiful art can be seen in many prominent buildings of the Timurid era. The rationality in their design and implementation is clearly seen in the study of the Ma'qelis. A Ma'qeli is a decoration that requires a lot of thinking for its design, and when the work is finished, any builder can implement it. Proportion is one of the most important features of Ma'qeli decoration. Unlike other brick decorations in glazed Ma'qeli, the bricks are not cut, but the necessary sizes are carefully calculated and a mold is used to make them[1]. It seems that these sizes are proportional to the dimensions of the building plan components and are obtained from the cutting of the same proportions in the building. Although in-depth studies have been conducted regarding the proportions of Timurid buildings and the bricks used in the construction of the buildings have been measured, no independent study has been found regarding the Ma'qeli, which is considered the main decoration of these buildings. Because it is directly in the direction of the observer's view, the facade of the building is very important in terms of proper proportion and arrangement, and it is considered being the building's costume. In this article, the ratio of different bricks used in the decoration of the facades of Khargerd Ghiasieh School is studied and analyzed in order to accurately determine and present the proportion between them and the various architectural components used in them.

Research Method

In this research, all Ma'qeli frames with inscriptions have been redesigned in different facades and have been calculated and analyzed. The number of these frames is 6, which are reproduced many times in similar building facades and they form a major part of the Ma'qeli decorations of this building. In their structure, these frames include a Ma'qeli script and anthology, and in this sense, they can represent all the Ma'qeli decorations of the building, considering that some of the existing decorations were damaged and lost over time. First, all of them were photographed, and then, faithfully and completely under the original dimensions of the frame on the building, and with attention to similar details, the decorations were redesigned and studied by the author using Photoshop software, so that the ratio of the bricks to each other and their ratio to the base-area in which are used, be carefully calculated and recorded. The study is quantitative (numerical calculation) and the final analysis is presented based on the number of bricks that make up the width of the work, as well as the joints between these bricks.

Research Background

Because of the importance of brick decorations related to architecture, in-depth studies of various aspects of morphology, aesthetics, and even semantics have been carried out, some of which are mentioned below: «Al-Saeed and Parman» (1983) in the book entitled «Geometric Patterns in Islamic Art» and «Ardalan and Bakhtiyar» (2011) in the book «Sense of Unity» discussed the basics of geometry and geometric motifs in Islamic art and discussed their practical and symbolic aspects. «Necipoglu» (2000) in the book entitles «Geometry and Decoration in Islamic Architecture», on the 10th chapter, has presented important materials regarding the proportion and aesthetics in the building. «Pirnia and Bozorgmehr» (2006) in the book entitles «Geometry in Architecture» and «Bemanyan,

Okhovat and Baghaie» (2011) in the book entitled «Application of Geometry and Proportions in Architecture», discussed the place of geometry and its application in Iranian architecture and the proportions that can be created in the building because of applying these sciences. «Azarkhordad» (2017) in her master's thesis entitled «Recognition and Analysis of Geometric Proportions of Timurid Era Buildings Based on the Works of Qavam al-Din Shirazi» has presented valuable information about the proportions of buildings such as Khargerd Ghiasieh School and Shrine of Zeinoddin Abu Bakr Tāybādi; however, they remained silent about the proportion of the decorations in these buildings. «O'kane» (2007) in the book entitled «Timurid Architecture in Khorasan», in the third chapter, in the description of building construction methods and materials, states that mathematics has a valuable role in Timurid architecture. Regarding the role of «Gaz» as a measuring scale in the structure and components of buildings and the relationship between the ratio of dimensions of bricks and the type of Gaz that was used in the building, he made a lot of efforts, which did not have a clear result. «Naima» (1997) in the book entitled «Dezful the city of bricks» has provided useful information about brickwork, especially the type called khavun-chini and the components of brick that are obtained by cutting the base-brick; however, he has remained silent about the decoration. «Zamershidi» (2005) in the book entitled «Iranian tiling, Ma'qeli script» and «Maher al-Naqsh» (1982) in the book entitled «Design and motif implementation in Iranian tile work of the Islamic period; First book, Bannai script», provides useful and practical information about the methods of implementing a Ma'qeli design and its types, but they do not provide information about the proportion of bricks in this art. «Keshavarzi Miandashti and Fizabi» (2017), in the article entitled «Typology of Bannai script (Ma'qeli), based on design and implementation methods», introduced types of Bannai script and stated the design method of each one; but they do not discuss the proportions between the components of this decoration. Only «Menkovskaya» (2000), in the article entitled «Towards the Study of Architectural Forms in Central Asia at the End of the 14th/8th Century A.H.: Mausoleum of Khwaja Ahmed Yasawi», mentioned the size of the bricks used in the facade of this building; but he says nothing about their proportion to building components. Therefore, the current research is seeking reporting the existing proportions in Ma'qeli decorations of buildings and reports the effective quantities in these proportions in the Khargerd Ghiasieh building on a case-study basis.

Types of brick decorations

«Zamarshidi and Sadeghi Habibabadi» have divided brick patterns into three major categories, including: Hasiri motifs, Jenaghi motifs and Khofte-Raste motifs (Zamershidi & Sadeghi Habibabadi, 2018, p. 15). Basically, the basis of brickwork in Iran is based on dividing the brick into smaller parts, which according to the resulting size and form, can arrange regular and beautiful shapes. The components of bricks in Iranian art, according to «Zamarshidi», include: «Chardang, Sedang, dodang, charkeh, pareh, shasti, qenas, and ghofli» (Zamershidi, 2007, p. 83). which are used in all kinds of brickwork, especially in the joints between bricks. Iranian bricks of the Islamic period are introduced by Mohammad Yusuf Kiyani in three sizes (20×20×5), (20×20×3), and (25×25×5) cm^2 (Kyani, 2003, p. 25). Khofte-Raste is one of the most famous brick decorations that has been used in all periods. It is based on the stability of one brick next to another brick: An absolute distinction that is the agent of change along the observer's gaze, creates beauty and variety. During the Timurid era, due to the tendency to use bright glazed colors, the plain rows of Khofte-Raste bricks gave way to decoration with glazed bricks. The most decorations were used with

60

applied using turquoise and azure on the pale goldenrod background. Examples of these works have been presented by Alizadeh et al. in their article (Alizadeh, Salehi, & Emamifar, 2013, pp. 65-68). The Bannai calligraphy is a script based on construction materials, both in terms of the type of materials and the way they are used in the building. Square and lozenge are the most important backgrounds in which this script is used[3]. An example of it, which is known as the Ma'qeli script, was used abundantly from the Timurid period and decorated many facades of the buildings of this period with pleasant forms and colors. «Maher al-Naqsh» introduces Ma'qeli as a type of facade design, which is used by placing squares or lozenges together to obtain a special and desired plan (Maher al-Naqsh, 1982, p. 9). In terms of execution, Ma'qeli is performed in three ways[4]: single-row (یکرگی), three-row (سه‌رگی), and stretched script (کشیده‌متن) (Maher-al-Naqsh, 1982, p. 14)[5]. Generally, the word (Golchin Ma'qeli) is used for Ma'qeli motifs and the word (Ma'qeli script) is used for the text. Using a square or lozenge background depends on the architect's opinion. In Ma'qeli, both bricks with simple and deformed ragchin (arrangement type) are used in bricks bonding. The first group is satisfied with the color contrast between the bricks, and the second group also uses the contrast of the shape change. In the meantime, the use of the Khofte-Raste arrangement technique, which was used by the architects of the Timurid period, achieves more beauty (See Figure 1). The Ma'qelis studied in this research have been worked on in a Khofte-Raste style, which will be analyzed further in subsequent sections.

Figure 1. On the right, the word Muhammad with a simple brick arrangement, which only the color contrast of the bricks makes the design work. On the left, the word Muhammad with Khofte-Raste brick arrangement (redesigned decoration from the Khargerd Ghiasieh school). Source: Author.

Khargerd Ghiasieh School; the last work of Qavam al-Din Shirazi

This building belongs to the 9th century A.H. The date of its inscription shows 848 A.H. The school building has four porches and includes two floors with chambers around. The design and division of the building is very complex and glamorous (Blair & Bloom, 2003, p. 74), which are decorated with facades covered with Ma'qeli and mosaic tiles. The founder of the school is «Khwaja Ghiyathuddin Pir Ahmed Khafi» and the architect of the building is «Qavam al-Din Shirazi». Samarqandi introduces Qavam al-Din as one of the four unique artists in Shahrokh's court in «Tadzkirah al-Sha'araa» (Samarqandi, 2003, p. 340). Qavam

61

al-Din's style was imitated by other architects until years later. The similarity of the decorations of the shrine of Abu Nasr Parsa with that of Khwaja Abdullah Ansari, which was built years after this building, is an example of this deliberate imitation (Fizabi, Javani, & Ghasemi Sichani, 2015, p. 112). Fortunately, the building is still available and has preserved the beautiful decorations of the 9th century architectural art with all its principles and rules (Javani, Kianmehr, Mahyar, and Seyyedi, 2017, p. 72). Researchers are of the opinion that Qavam al-Din has his own special style in Iranian architecture (Golombek & Wilber, 1995, p. 259). This building is one of the most interesting buildings of the Timurid period (Hill & Graber, 2007, p. 88). The decoration on the exteriors of the building is a combination of very exquisite mosaic tiles and glazed bricks in a Ma'qeli style. On all sides of the external facades, there is a Ma'qeli work, which includes both the Golchin and Ma'qeli script arts[6]. The Ma'qeli style based on the Maher al-Naqsh division includes single-row (یکرگی), three-row (سه‌رگی) , and stretched script (کشیده‌متن) , which are worked in a Khofte-Raste design (See Figure 2).
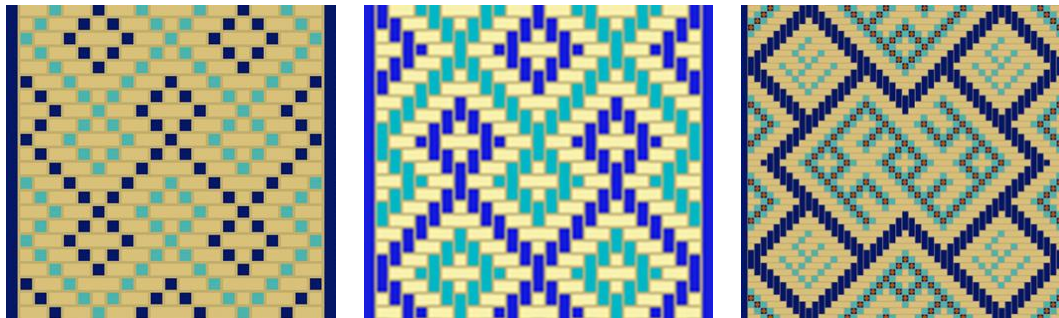

Figure 2. On the right, a single-row Ma'qeli, in the middle, a stretched Ma'qeli text, and on the left, a three-row Ma'qeli (in the words of Muhammad and the surrounding half-lozenges), which are used in different facades of the building (redesigned decorations). Source: Author.

The structure of Ma'qeli decorations in the facades of Khargerd Ghiasieh School

In Ma'qeli art, the ratio of bricks to each other is generally 1-2-3. 1 is a square whose side is the width of the base-brick. 2 and 3 are the number of squares that are placed in a row and make the larger components of Ma'qeli bricks. All the beauty of Ma'qeli is in their order and arrangement according to their rules, which should be completely related and proportional to the used base-area. In this building, due to the fact that the decorations are made in Amud[7] style, the base clay differs from the clay used in the building's construction. The base clay in the structure is 6×25×25 cm according to «O'kane's» report. In Iran's brickwork tradition, the base clay is cut according to certain principles and creates different bricks in correct proportions. The bricks in the Ma'qelis of the Timurid period are generally colored and one surface of the brick is covered with glaze (See Figure 3).
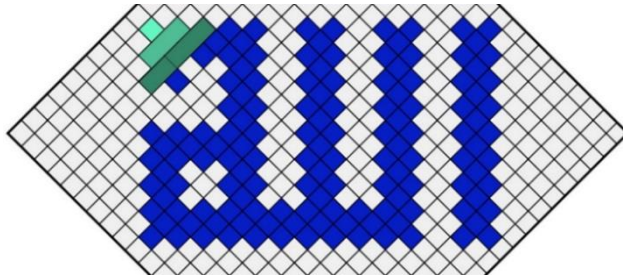
Figure 3. Designing and drawing the word الله with the ratio of 1-3-5, which is common in most Ma'qeli scripts. The proportion of bricks used can be seen on the upper left side. In practice, to cover the large ratio with 5 squares, one brick with the size of 3 and one brick with the size of 2 squares is used without decorative joints (drawing). Source: Author.

In the Khargerd Ghiasieh school, based on the measurements that were made at the building site, the ratio of square brick to adjacent bricks in the combination of Ma'qelis, considering that there is a decorative joint between each brick and the other brick, is as follows (See Figure 4). A square brick with a side length of approximately 4.25 cm, a medium brick with a length of approximately 9.6 cm and a width of 4.25 cm, and a large brick with a length of approximately 14.95 cm and a width of 4.25 cm are three parts that form the foundations of this building[8]. Since there is a 5-square brick in the design of the Ma'qelis, in practice, a large brick (3 pieces) and a medium brick (2 pieces) are used in the same length without a decorative joint in between (See Figure 5). Therefore, the relative size of each brick as seen in the schematic plan (See Figure 3) include: the length of the large brick is three times the length of the small square brick plus two brick joints and the size of the medium brick is equal to two small square bricks plus one brick joint. The thickness of the brick joint is about a quarter of the side of a small square brick (Seyyedi, 2019, p. 101). With a detailed examination of the glazed bricks used in the Ma'qelis of the Khargerd Ghiasieh building, it was observed that three molds with the aforementioned sizes were used for the construction and execution of the Ma'qelis, which were finally covered with turquoise and azure glazes and burned.
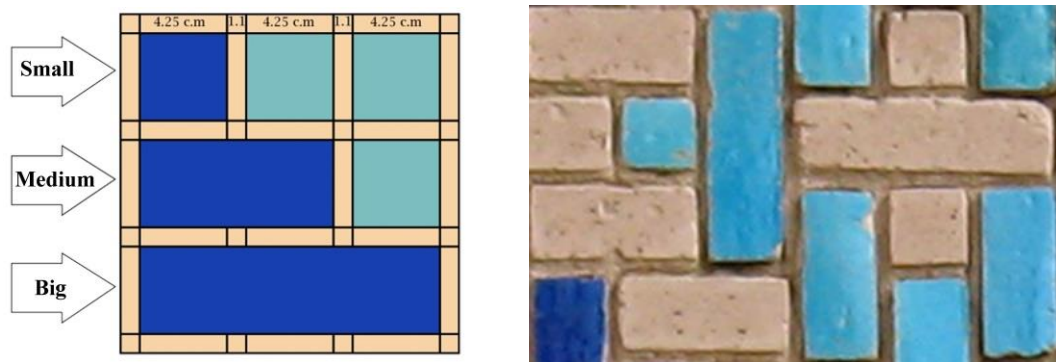

Figure 4. The structure of the proportion of bricks used in various brick and tile decorations in Khargerd Ghiasieh School. Source: Author.

63

Figure 5. Display of details in the Ma'qelis of the Khargerd Ghiasieh School. As can be seen, the size of 5 squares is used with one brick (3 pieces) and one brick (2 pieces) without a joint between the bricks. Decoration under the porch of the side entrance from the west front to the mosque. Source: Author.

While in brick decoration, especially the style (khavun-chini), the required bricks are obtained and used by cutting the base-brick (Naima, 1997, p. 52). The reason for this difference can be found in the small number of bricks required for implementing a Ma'qeli, which only requires three sizes of bricks in certain proportions. From a field study on the method of making glazed bricks that was carried out in the traditional tile workshop of Awqaf Mashhad, it was found that the bricks used in Ma'qeli are made according to predetermined sizes and are made, glazed and burned using molds. Considering that the bricks used in the Ma'qeli decoration of the building are made with only the mentioned three sizes, it should be found how many bricks and of what sizes were used to decorate a desired frame in the building's facade. During the Timurid era, various sciences flourished a lot. Applied mathematics was widely used in architecture. «Ulugh Beg's» support to scientists in Samarkand led to the construction of his huge observatory, which was one of the largest centers of astronomy and calendar in its time. Ghiyāth al-Dīn Jamshīd al-Kāshī dedicated a chapter to architecture in «Meftah al-Hesab» which dealt with metrology, calculation of arches, and formulas for calculating plane areas. Studies show that the calculations of Timurid architects were not based on arithmetical calculations, but on geometric drawings that generate proportions between components (Kostof, 1986, p. 62). Based on the studies, Iranian architects used to draw plans on checkered surfaces so that they could consider the exact proportions of different parts compared to the overall size of the building. The dimensions of the entrances, load-bearing elements, and the thickness of the walls are mentioned in this plan. Of course, they always used the dynamic square principle (Carre Dynamique) to fit the proportions of the building (Azarkhordad, Zarei & Hashemi Zarchabadi, 2018, p. 183). According to Tarikh Khairat, regarding the construction of Timur's Delgosha Palace, after the design of the building was completed and when the walls were raised a little, artisans in various fields such as tile makers, stonemasons, painters, carpenters, and weavers started their work at the command of Timur himself (Pugachenkova, 2008, p. 32). This shows that not only the floor plans but also the facade plans were prepared before the construction of the building, in such a way that each of the artists and craftsmen could carry out their work independently. Usually, during the Timurid era, the plan of the building was drawn on square checkered papers, which were measured in Gaz units. The size of this unit is not fixed and differences can be seen in the examination of different buildings. According to «Menkovskaya 's» research conducted on the shrine of

PAYKAREH
Journal of Art Faculty, Shahid Chamran University of Ahvaz
Examining the Proportion in Ma'qeli Decorations of "Khargerd Ghiasieh" School
Volume 11 Issue 29 Autumn 2022   Page 57-71
64

«Sheikh Ahmad Yesvi», the size of each Gaz is 60.6 cm. This size has been reported in other buildings as 67.2, 60.8, 67.5, 62., etc. meters. The research studies of «Kryukov and Baklanov» provide different results, which have been a great help in correcting the previous results. It seems that Gaz was the basis of the building design and other dimensions of the building were considered, with coefficients of this size. In other words, Gaz was used as a Peymoon in architecture. It has not been proven whether the size of the bricks used in the building is proportional to this traditional unit, but there are many similarities in this regard (O'kane, 2007, p. 81). Gaz size in the buildings built by Qavam al-Din is reported to be 60 and 60.8 cm (O'kane, 2007, p. 80). The bricks used in these buildings are also reported with a slight difference in dimensions.
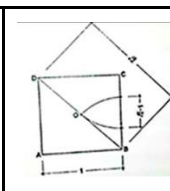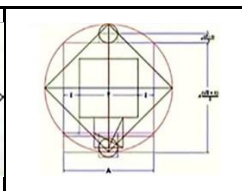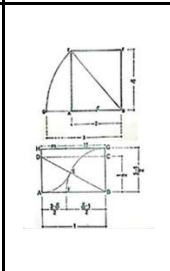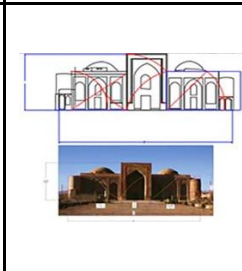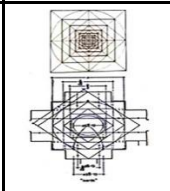
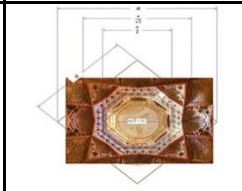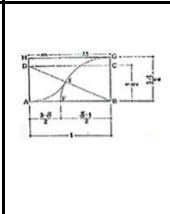|			
Plan	Using base 1 ($\sqrt{2}$) and its derivatives $$\frac{\sqrt{2}+1}{2}$$		
Vertical segment of the facade	A combination of base 6 (semi-square and $\sqrt{5}$ ratio) and base 8 (root 5 of a rectangle and $\sqrt{5}$ ratio) and its derivatives $$\frac{\sqrt{5}-1}{2}$$		
Eastern dome house and Karbandi	Using base 1 and concentric squares with growth principle $\sqrt{2}$		
Porch	Using base 8 and base 6 (root 5, right corner) and diameter of the square along with the complementary rectangle		

Figure 6. The various elements of the Khargerd Ghiasieh school and the existence of ratios based on the common geometrical rules of the time in the components of this building according to Azar Khordad. Source: Azarkhordad et al., 2018, p. 92.

Calculation of Ma'qeli decorations containing Ma'qeli script in Khargerd Ghiasieh school

The decorations that have a Ma'qeli script include: the holy words of الله as Mosanna (paired) and inverted on the front of the facades located on the southern front of the building, الله and محمد in the facades around the main entrance of the building, الله and محمد in the form of Mosanna (paired) and inverted at the entrance to the building on the western front, محمد and علی in the main decoration under the eastern porch and و الله احد and الله صمد under the entrance arch of all the rooms on the first floor. The aforementioned decorations are studied and calculated to achieve the desired goals.

65

1. The word الله in the form of Mosanna (paired) and inverted in the view of the decorations in the protrusions on the Qibla side: this decorative frame is used four times above the four arches that are on the front of the Qibla side. This frame is surrounded by a Ma'qeli Golchin, where the intended text shines like a jewel on the forehead of these arches (Figure 7). The width of the work is formed with 49 small bricks (squares) which are separated from each other by 50 joints between the bricks. The decoration is done around with a single-row Golchin Ma'qeli and in the middle with a stretched Ma'qeli script. The arrangement of the Ma'qeli script Khofte-Raste. All the text bricks are turquoise and the background bricks are colorless (unglazed bricks). All three small, large, and medium bricks are used in this decoration, and in the corners, a large and medium brick is used without a joint between them (instead of a brick with a ratio of 5). All الف in this script are formed with medium bricks to create the necessary balance in the proportions. The frame is surrounded by an Azure brick, the width of which is 273.25 cm in total.
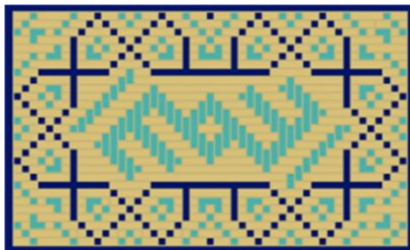

Figure 8.الله, Mosanna and the reverse of a part of the exterior decorative facade of the building on the Qibla side. Source: Author.

Figure 7.الله and محمد in the form of Mosanna and inverted under the arch of the entrance to the mosque from the west. Source: Author.

2. Decorations under the sub-entrance arches of the eastern and western fronts: From the west side of the building, there is an entrance to the mosque space, which is decorated with a Ma'qeli under the arch of this entrance. The text of the inscription comprises the holy words الله and محمد in the form of Mosanna (paired) and inverted, with الله at the top of the arch and محمد at the two sides of the entrance symmetrically (Figure 8). The width of this work comprises 27 small bricks separated from each other by decorative joints. In this decoration, Ma'qeli calligraphy and Golchin Ma'qeli have been used together. In this work, small and large bricks are used and the medium brick is used only in the corners and next to the large brick without a joint between the bricks to create a 5 square ratio. The number of joints separating the bricks is 28. This decoration is also covered with an azure brick. Based on this, the width of the decoration with the algebraic sum of the existing values is 154 cm.

3. Decoration of the arches of the main facade near the towers of the complex: there are two similar arched facades on both sides of the entrance porch on the northern front of the building near the towers, in which there is a Ma'qeli design with inscriptions with the holy words الله and محمد (Figure 9). The design includes 39 square bricks and 40 decorative joints between the bricks. Ma'qeli is a type of stretched text that is decorated around with a Golchin and in the center with a Ma'qeli script. In this frame, three small, medium, and large bricks are used in the design's implementation. The medium brick is used in the corners and along the length of the large brick without decorative joints. The entire frame is surrounded by a small brick. The width of the work obtained from the algebraic sum of all sizes is 218.25 cm.
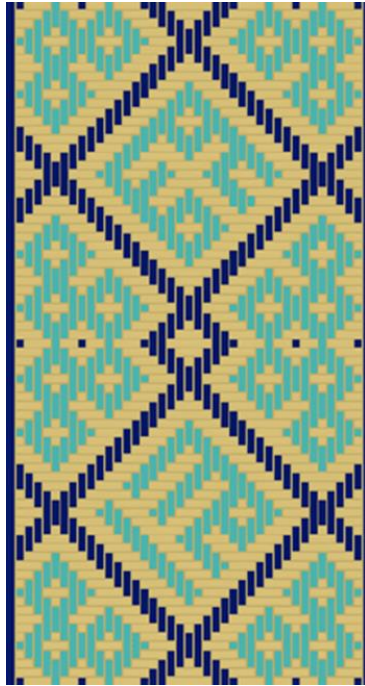
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Journal of Art Faculty, Shahid Chamran University of Ahvaz
Examining the Proportion in Ma'qeli Decorations of "Khargerd Ghiasieh" School
Volume 11 Issue 29 Autumn 2022   Page 57-71
66

Figure 9. The words الله and محمد
worked in the text of the arches in
the north front of the school.
 Source: Author.

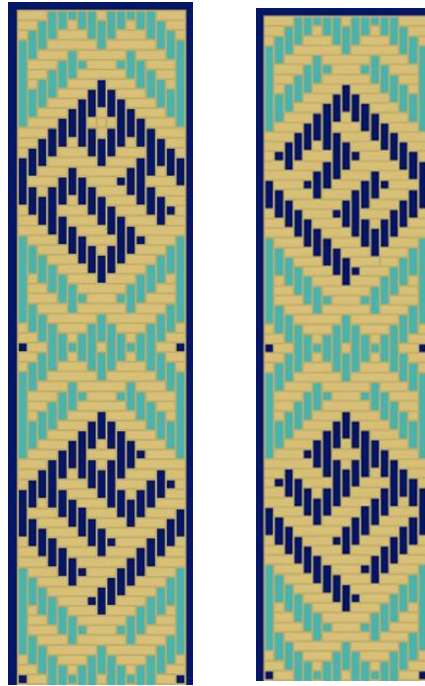**Figure 10.** Ma'qeli, الله صمد and و الله احد
designs worked on the side walls of the
entrance to the rooms on the first floor of
the building. Source: Author.

4. Decorations under the arch and the side walls of the chambers on the first floor of the building: these designs are used at the entrance to all the chambers of the building except for the corner ones. Two designs are the same in terms of execution and size, only in terms of the text, "احد الله" is drawn in one and "صمد الله" is drawn in the other, and they are placed in the middle (Figure 10). Here, unlike the previous examples, the inscription occupies the entire width of the frame. Except for the difference in the inherent form of the words (احد and صمد), no other difference can be observed in them. They have been designed and implemented using the characteristics of the Kufic Bannai script in such a way that they are very similar, and present similar values in terms of size and surface. The width of the work is 17 small bricks, which are separated from each other by 18 brick joints. Finally, the entire work is surrounded and framed with a small azure brick. Accordingly, the width of the work is 100.55 cm. Like other decorations with inscriptions, all three small, medium, and large bricks have been used here.

5. Decorative decorations under the arch and the side walls of the eastern porch of the building: this type of decoration is used only in this part of the building and has no other example. All three Ma'qeli methods of single-row (یکرگی), three-row (سهرگی) , and stretched script (کشیدهمتن) are used in a combined manner, and a very interesting distinction can be seen between each component (Figure 11). The decorations are executed with three colors of turquoise, azure, and mustard yellow in the background with colorless bricks. The main framing of the geometric design is done in azure and words, and part of the decoration of the elements of the design is dominated by turquoise color to create the necessary contrast in all the components of the design. Considering the location of the design and the fact that

67

this frame is placed in the heart of countless other decorations that have various colors, based on the governing order and color arrangement, the decorations of this building, which itself is based on very interesting rules. In its Ma'qeli implementation, all three common methods of the time have been used and besides turquoise and azure colors, mustard yellow has also been used. The word محمد in the center of the decoration and the decorative lozenges around the frame are decorated with a three-row Ma'qeli style, in which three rows are used in the middle brick, in two colors of azure and mustard yellow. If we resemble these three bricks placed together in a ring, then the middle brick is like a jewel that shines on it. Therefore, «Maher al-Naqsh» calls these decorations «jeweled Ma'qeli decoration». The width of the work is 49 square bricks, which are separated from each other by 50 brick joints. Based on this, the width of the work is 273.25 cm. In all the frames, the background bricks are horizontal and colorless and the vertical bricks, making the designs with two colors of turquoise and azure, are used. All the decorations are surrounded by the horizontal arrangement of a medium brick (2 squares) without color, which is repeated in all the frames, so it is avoided to sum their size with the width of the work.

Discussion

Based on the present study, all the Ma'qelis are arranged with only three sizes of bricks. Considering that these bricks should decorate the desired base-areas (without cutting), therefore, in terms of dimensions and size, they should be a correct fraction of all the desired bases in the building. As mentioned earlier, the basis of all sizes was in Timurid architecture (Gaz), which led to the adoption of Peymoon used in the building. Once the size of the Peymoon is determined, the floor plan is converted into a checkerboard and the building components are calculated, drawn, and determined based on these checkers. According to the Tarikh Khairat report, it is concluded that not only the dimensions of the floor plan but also the dimensions of the facade plan were intended and carefully determined in the building's design from the beginning (Pugachenkova, 2008, p. 32). With the knowledge obtained from Qavam al-Din Shirazi, he was one of the greatest architects of this era. The studies conducted on the elements of his buildings, including the Khargerd Ghiasieh School, which is under discussion, show the use of geometry and golden dimensions in their construction. Accordingly, the decoration of the facades, which organizes the most important visual aspects of the building, cannot be free of these architectural and aesthetic features; therefore, the dimensions chosen for the bricks should be in such a way that the views seen by the observers can be displayed in the best way and avoid any kind of inaccuracy and irregularity. By determining the length and width of the different areas in the building components, the tile artist has chosen his brick components in such a way that, first, it is a correct fraction of the desired base-area length and width, and second, it can be applied to all the desired areas, because it is not possible to use a separate brick for each area. Due to the fact that the Peymoon or the square that fits the components of the building in traditional Iranian architecture is not based on the numerical calculation that is obtained based on the geometric drawings, the square of the brick base used is also the result of the same geometric drawings. However, other division conditions should also be added, such as the odd number of squares in the width and the length of the work, the distance of the bricks from each other, etc. Therefore, it is possible that the dimensions of the bricks do not end with a whole number in terms of size, and as can be seen, the dimensions of the base square and, by nature, the bricks used in decoration, generally have decimals. In the study of the Ma'qelis of the school building presented in Chart 1, it shows the number of bricks

Figure 11. محمد in reverse and Mosanna form and علی in simple form in the main decoration under the eastern porch. Source: Author.

68

and their size ratio. While the Gaz used in Ghiyathiye school is 60.8 (O'kane, 2007, p. 80), the widths of the decorated tiles are 1.63, 2.53, 3.59, and 4.49 Gaz, respectively. It is considered that all of them can be covered with the correct number of small square bricks. In other words, the checkered grid intended for drawing the Ma'qelis, which includes square bricks and decorative joints between the bricks (4.25+1.1) is a square with a side of 5.35. Of course, in order to reach the base square, besides the correct number of bricks, their being odd has also been one of the principles and requirements in this building. As seen, the width of the decorations in six studied frames is odd. The number of odd squares is the basis of similarity in the design of traditional arts. Symmetry in traditional Iranian arts should be considered as a form of all arts, which itself has a mystical basis. Of course, it should be mentioned that all these decorations, besides being surrounded by a square glazed brick, are surrounded by a medium-sized unpainted brick (two squares plus a joint of bricks), which should be added to the width of the work to achieve the final size of the desired frames. For example, the width of the decoration of the arch of the main front is: 39 square bricks, plus 2 azure square bricks around and 2 medium colorless bricks that form the desired arch. In other words, 45 square bricks plus 46 j between the bricks $\{(1.1\times46)+(4.25\times45)=241.85 \text{ cm}\}$ which is 3.98 or approximately 4 Gaz in this building. Many other facades in this building, which are decorated with a Ma'qeli style and all of them are used in a Khofte-Raste arrangement, have the same proportions in them, and not even in one case, a contrast can be seen.
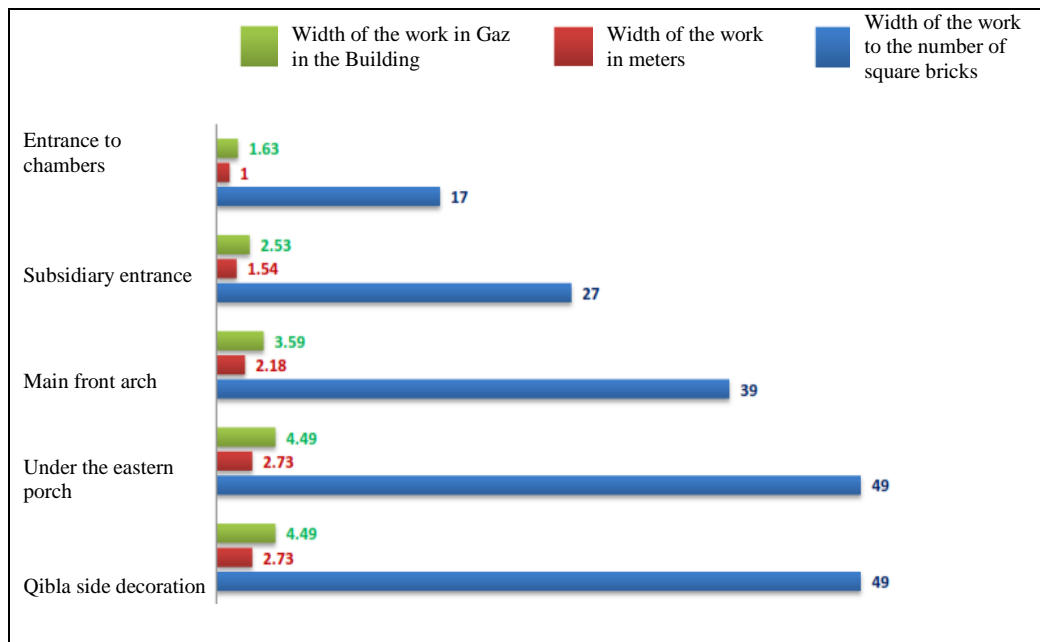

Chart 1. The number of bricks, size in meters, and size in Gaz, across the measured frames. Source: Author.

Conclusion

The following results are presented from the study and the objective investigations that were carried out on the redesigned decorations of the authentic Ma'qeli on the building structure: Regarding the purpose of the research that studies the proportions of the Ma'qeli in the "Khargerd Ghiasieh" School, it was determined that the size of the bricks used in Ma'qeli

69

in a calculated way that is always proportional to the spaces that have been decorated; That is, the ratio of bricks and joints between them is always a correct fraction of the desired location. This fact can be seen in diagram 1. In the area under the main porch on the eastern front, under the entrance to the mosque on the western side, or any other place decorated with these bricks, these correct proportions have been carefully calculated. Due to the fact that the divisions and sizes of Timurid architectural components were traditionally proportional based on (Peymoon) and through geometric drawings, the size of the bricks in the decoration should also be obtained through geometric drawings. The presence of decimals in the size of bricks is an obvious proof of this claim. In choosing the base square for the construction of bricks, the dimensions are chosen in such a way that the right number of bricks are used in all the facades to be decorated, including the foundation facade, the depth of the entrance to the porches and the arch facades in the exterior facades, and there is no factor that can distort this eye-catching proportion between the length or width of the decorated area. This proportion becomes important when an odd number of bricks are used in the length and width of all the facades studied to create a similar and eye-catching pattern. In order to achieve these proportions, the architect never had to think of another arrangement or take another step to make the patterns proportional. Despite the fact that for making Ma'qelis, especially colored Ma'qeli, it is possible to use a simple arrangement, here, in all Ma'qelis, whether inscriptions or Golchin, Qavam al-Din uses a Khofte-Raste arrangement to increase the contrast between the background and motifs and provide more beauty. This artistry reaches its peak in the combination of three common styles in one design, especially in the jeweled three-row Ma'qeli under the eastern porch of the building, and it shows the power of using balanced proportions in his work.

Appendix

1. Observing the method of preparing special bricks in Goharshad traditional tile workshops and Astan Quds Razavi traditional tile workshop in Mashhad.

2. It seems that these sizes have been very frequent, otherwise, in a few buildings, very diverse sizes outside of what has been reported have been reported (author).

3. In addition to square and lezenge, the Kufic Bannai script can take different forms depending on the shape of the place where it should be used (Maher al-Naghsh, 1982).

4. In his book, Zamrashidi has divided Ma'qeli into two categories in terms of performance. Single-row and three-row (Zamershidi, 2005, p. 159). He assumed that three-row and stretched script are the same and consider them to be different modes of the same method (author).

5. In a single-row Ma'qeli, the size of the square forming the design is a correct fraction of the size of the negative space between the areas. But in a three-row Ma'qeli, the positive and negative background of the desired design is the same, which is created by the linear joining of three single-row square bricks. The color of the middle brick is different and contrasting with other bricks. In Ma'qeli stretched script, the squares that make up the positive space are not separated from each other and are placed along each other, and the positive and negative space are equal. Kashavarzi Miandashti and Fizabi called Ma'qeli's stretched script the Khofte-Raste (Keshavarzi Miandashti & Fizabi, 2017, p. 55). This type of Ma'qeli is also used as a simple arrangement; For example, Figure 1 (on the right) in the present article (author).

6. On the north façade and pillars of the entrance porch and behind the sides of the gables, they have also used mosaic decoration.

7. The decoration that is added after the construction is finished.

8. It seems that the size of the bricks used in the facades of different buildings are different, just like the bricks of the structure. According to Mankovskaya's report about the decorations of the Sheikh Ahmed Yesavi building, the Ma'qeli bricks in this building are also made in three sizes, which are: small brick, 4.8×4.8 cm, medium brick, 4.9×11 cm (twice plus the length of one joint ١/٤ cm) and large brick, 17.2×4.8 cm (three times plus the length of two joints) (Mankovskaya, 2000, p. 266). Note: It seems that the size of 4.9 for the average brick is a typographical error, because in the Ma'qeli, the width of all the bricks should be the same and equal to the side of the square brick.

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