A Study on Geometric Constructions on Brickwork Decorations in Iranian Architecture

Mahsa Kharazmi
Excellence Cluster Topoi, Freie Universität Berlin
Museum of Islamic Art, Berlin
Geschwister-Scholl-Str. 6, 10117 Berlin, Germany
kharazmi.mahsa@gmail.com

Abstract

As a primary medium of decoration, brick was also used as the main structural material in the early Islamic buildings in Iran. The advancement in construction and innovation of glazed bricks led to development of brickwork decorations during the Seljuq dynasty in Iran and a variety of design were created in brickwork decorations and applied in most of the buildings of this period. Since brickwork decorations were constructed by arranging vertical, horizontal, and oblique of small pieces of bricks, the final patterns appears as plaid textures on the buildings. However, taking into account their substructure, a sort of geometric construction could have been proposed for their design. Based on the aforementioned hypothesis, some examples of brickwork decorations from Iranian Islamic architecture have been analyzed in this paper. The analyses are carried out by considering the whole ornamental patterns in order to extract assumed methods and geometric divisions for their substructure.

Introduction

Brick was one of the main ornamental material in Iranian architecture, from the early Islamic to the Seljuq period. In most of the earliest examples, brick was involved beside the medium of construction to produce visual texture to the buildings. In this way, brickwork was not separated from the structure and it was constructed very simple by different arrangements of bricks during the construction of the buildings. In the later periods, brick gradually received an independent decorative character and a variety of designs had been generated in brickwork decorations. Therefore, as the first form of dominant decoration in Iranian Islamic architecture and the effective element on the further decorations like tiling, brickwork should be investigated deeply in the history of Iranian architectural ornaments. Moreover, study the methods of design of brickworks can provide valuable information about the history of design in Iranian architectural ornaments. Thus, this research looks into the design methods of some distinguished brickwork decorations of Iranian architecture and explores their substructure of designs.

The application of bricks in decorative pattern and in the framework of almost equal pieces that were arranged vertically, horizontally, and obliquely, were resulted in a king of visual plaid texture on the buildings. However, this paper tries to investigate the primary designs of these plaid grid brickworks in order to extract the geometric substructures of these decorative patterns and support this idea that brickworks were constructed based on geometric constructions rather than based on plaid grids. Several examples from the exclusive brickwork decorations of Iranian Islamic architecture are selected in order to provide a general attitude to this kind of decoration; and also to obtain reliable clarification on their geometric constructions.

Brickwork in Iranian Architecture

As the main material of construction in buildings as well as the decoration, brick plays a dominant role in the history of Iranian architecture. Although brick decoration was used in the pre-Islamic period, the application of brickworks was mainly extended during the Islamic period, especially in Seljuq architecture in Iran. This kind of decoration had been flourished by creating significant patterns as well as applying glazed bricks.

The earliest appearance of brickwork in Islamic architecture can be observed on the tomb of the Samanids at Bukhara, 10^{th} AD century, where brickwork decorations involved in the medium of construction of the building [5]. Therefore, there is no clear border between decoration and construction in this building [1]. Brickwork decorations, as one of the main characteristics features of Islamic architecture, spread from Central Asia to the rest of Iran and Anatolia [5]. This kind of decoration extremely developed during the Seljuq period from the middle of eleventh to the thirteen century and it was especially extended in decoration of the tomb towers and minarets [3]. The common method of brickworks in the early Islamic architecture was a kind of arranging the bricks horizontally and vertically [1]. However, the manner of laying bricks changed into the more complex patterns as well as constructing these patterns on the carve surfaces during the further centuries. Despite the development of other decorative techniques, brickworks considerably remain as a major ornamental material in Iranian Islamic architecture [5].

Geometric Analysis of Brickwork Decorations

In this part, brickwork decorations of Iranian architecture are selected to be analyzed. Each example is analyzed separately and their geometric substructures are discussed. The examples are discussed chronologically in order to present the evolution process of brickwork decorations and providing a general approach by these analyses. The whole designs are also categorized based on the symmetry groups. Since this paper tries to extract the substructure of designs of brickworks, the interlacing strips that are added to the final patterns as decorative elements are not being considered in extracting the symmetry group of each brickwork decoration.

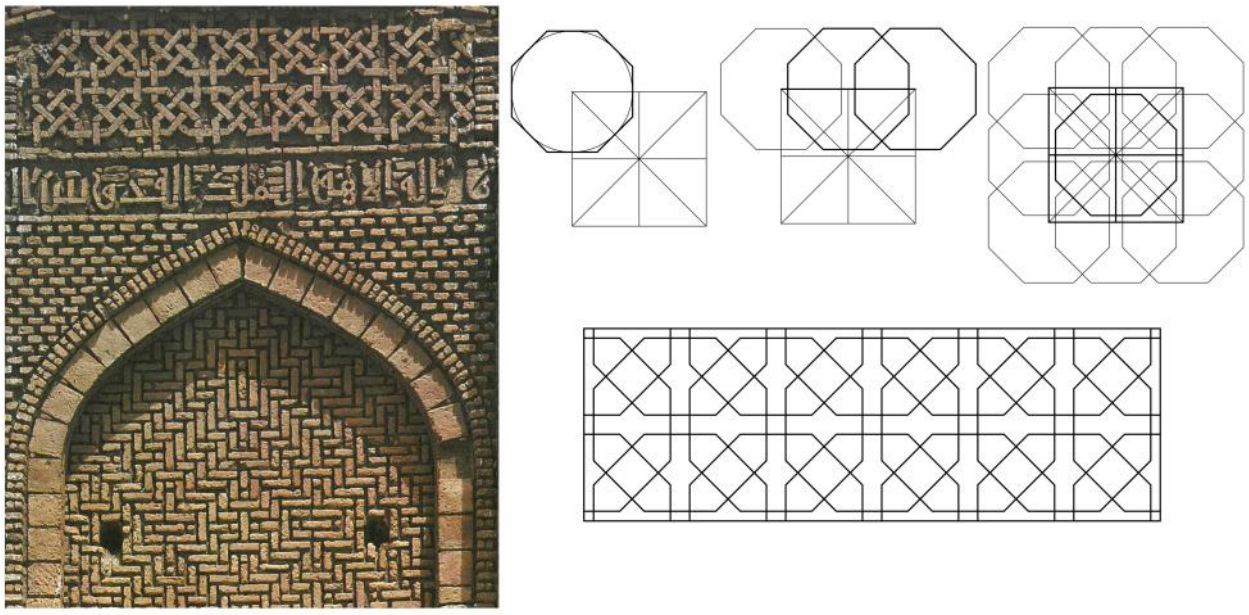

Figure 1: *Brickwork decorations in Kharraqan tomb and the analysis of substructure.*

The two Kharraqan tombs (dated 1067-68 AD and 1093 A.D.) are in the northern Iran, southeast of the city Qazvin. These monuments are remarkable for their brickwork decorations [4]. These famous Seljuq monuments are adorned with decorative brick patterns which display around seventy different brick designs [6]. In this paper, two different brickwork patterns of these monuments are selected to be analyzed.

Decorative brick band in Figure 1 represents a kind of common pattern in geometric design of Islamic architecture. The analysis of its substructure shows that this pattern is created by the transformation of one octagon. First, draw an octagon inside a square with a radius smaller than half of its side. Then, this octagon should be transferred to the square's corners as well as the middle points of its sides. This square should be symmetrically transferred based on its sides to complete the substructure of design of this decorative brickwork. This design has the symmetry type denoted *p4*.

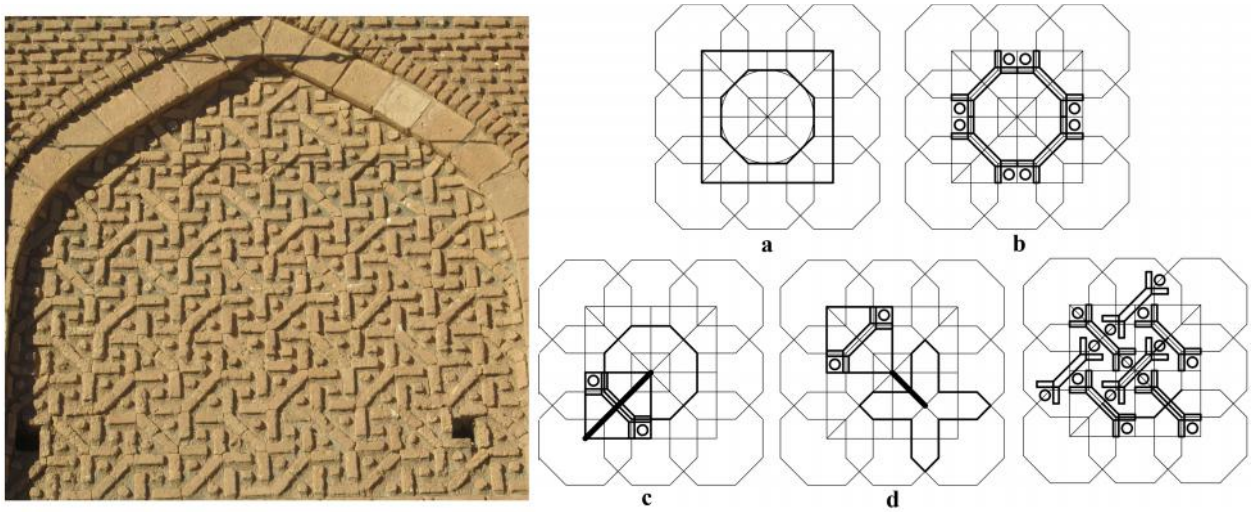

Figure 2: *Brickwork decorations in Kharraqan tomb and the analysis of substructure.*

The proposed substructure for brickwork decoration in Figure 2 is another example of brickwork decoration in Kharraqan tomb. For depicting its substructure, the diagonals of the square is depicted and then a circle is drawn with the center located at the intersection point of the square's diagonal and with the radius equal to half of the square's radius, Figure 2 a. Then, a circumscribed octagon is drawn and it is transferred to the square's angles as well as the middle points of its sides. In Figure 2 b, decorative motifs are drawn based on the first octagon's sides. For completing this design, the last motifs should be transferred by two different vectors. As it is shown in Figure 2 c, the first transition is based on a vector from the center of one octagon to the center of the other octagons and the next transition in Figure 2 d, is based on a vector from the center of one octagon to the center of the cross form shape which is shown in bold in the figure. This pattern follows *p4gm* type of symmetry groups.

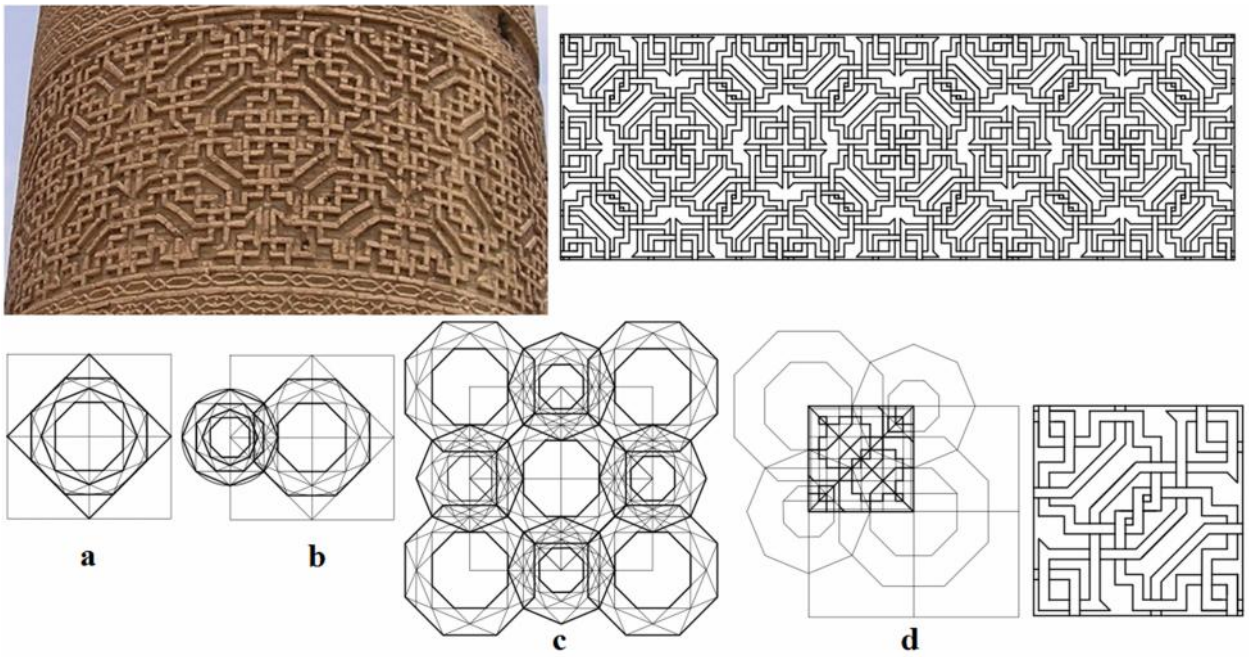

Figure 3: *Brickwork decorations in the Friday mosque of Saveh and the analysis of substructure.*

Figure 3 shows a detailed part of brickwork decorations of minaret of the Friday mosque of Saveh which was built in 11^{th} or 12^{th} AD during the Seljuq period [1].

The proposed method for constructing the substructure of this design is shown in five steps in the figure. First, connect the midpoints of square's sides to each other to create another square inside the first one. Then, an octagon is inscribed this square. After that, connect every second corner of the octagon to create another octagon inside the first one and again connect every second corner of the new octagon to create another octagon inside like in Figure 3 a. Then, draw a circle with the center at the middle of the first square's side and by the radius equal to the smallest octagon's side as it is shown in Figure 3 b. Based on Figure 3 c, transfer these patterns symmetrically with respect to all sides of the square. In Figure 3 d, a quarter of the pattern is depicted. In this step, some lines are drawn perpendicular to the octagon's angles and the main motif is extracted based on these lines. For completing the pattern, the last pattern should be transferred with respect to the lines of symmetry. This design has the symmetry type denoted *p4*.

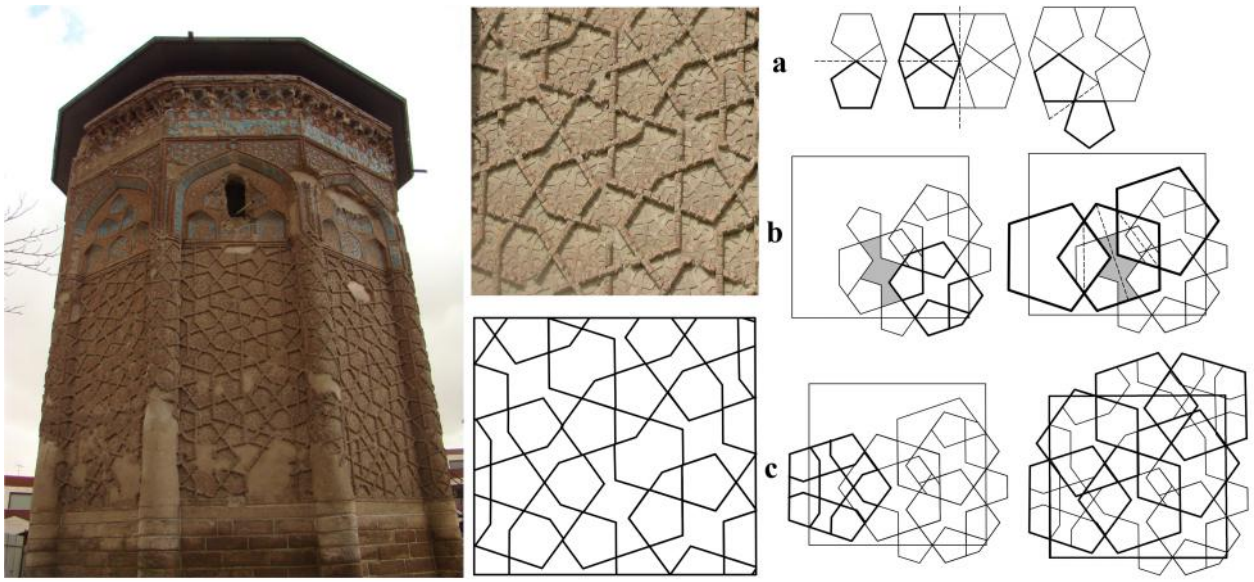

Figure 4: *Brickwork decorations in Gunbad-i Kabud tomb and the analysis of substructure.*

Gunbad-i Kabud is an octagonal tomb tower at Maragheh, in the northwest of Iran. This building was built in 1196-97 AD, during the Seljuq period. The detailed pattern in Figure 4 shows brickwork of the wall of the tomb that the walls are covered with a network of the motifs. These motifs are mainly composed of pentagons and hexagons [6].

The geometric construction that is proposed for the substructure in Figure 4 is based on the transformation of one pentagon and the other motifs are created among its repetition. As it is shown in Figure 4 a, one pentagon is reflected across the horizontal line from its top vertex and then, the sides of the two obtained pentagons are extended to meet each other. Finally, one vertical line is drawn from the intersection and the two pentagons are reflected across this vertical line. Hence, one unit is created to complete the decorative pattern. As it is shown in Figure 4 a, this form of transition should be repeated for other pentagons in the next steps. In Figure 4 b, the repetitive unite is rotated to fill the selected frame. Some other large pentagons can be extracted from the substructure of design that are shown in bold in Figure 4 b. Now, based on Figure 4 c, one of the primary small pentagons is drawn at the center of the left large pentagon and its sides are extended to create other motifs inside the large pentagon. The final step in Figure 4 c displays how the selected frame is completed with the reflection of these underlying pentagons. The analysis of this brickwork reveals interesting methods of design by the rotation of one motif in different sides and by considering accurate geometrical divisions to create a unique pattern.

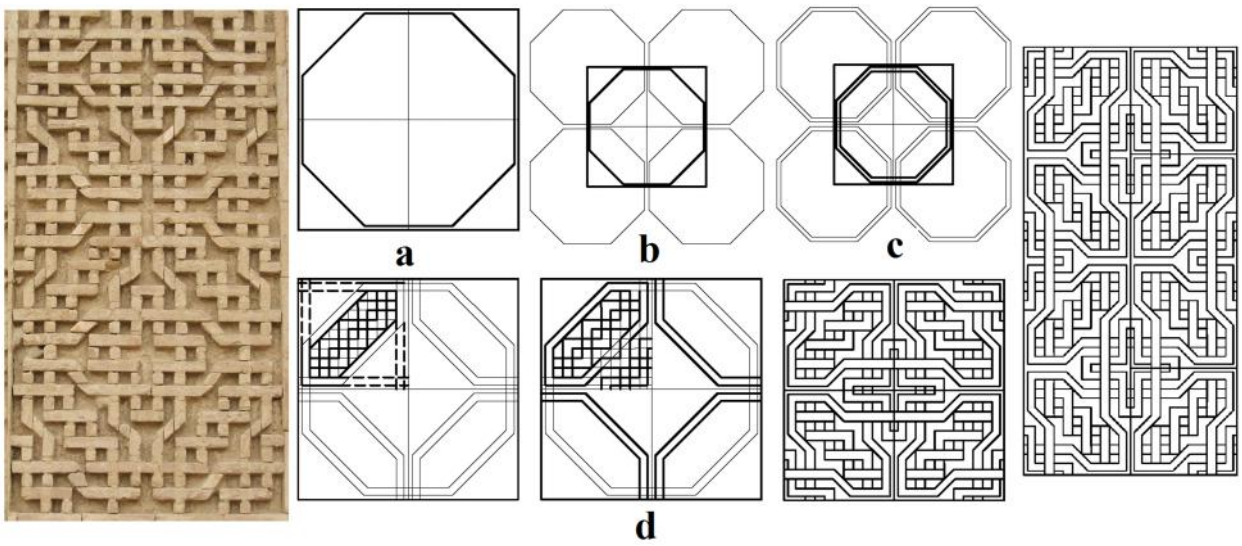

Figure 5: *Brickwork decorations in the Friday mosque of Gonabad and the analysis of substructure.*

The Friday mosque of Gonabad in the northeast of Iran dates back to the 1204 AD. Figure 5 shows a part of brickwork decoration of this mosque. The geometric substructure of this brickwork design is shown in Figure 5 a-d. One octagon is drawn inside a square. Then, the octagon is transferred based on the vertexes of the square which is shown in Figure 5 b. In this step, the interior division of the square is created. In Figure 5 c, the interlacing strips are added to the octagons. Now, one square with interior divisions is prepared. This square is the repetitive unit for completing the brickwork decoration. As it is presented in Figure 5 d, a quarter of the square is designed by dividing its surface and then the square is filled symmetrically. The rest of this design is drawn by repetition of the square. This design has the symmetry type denoted *c2mm*.

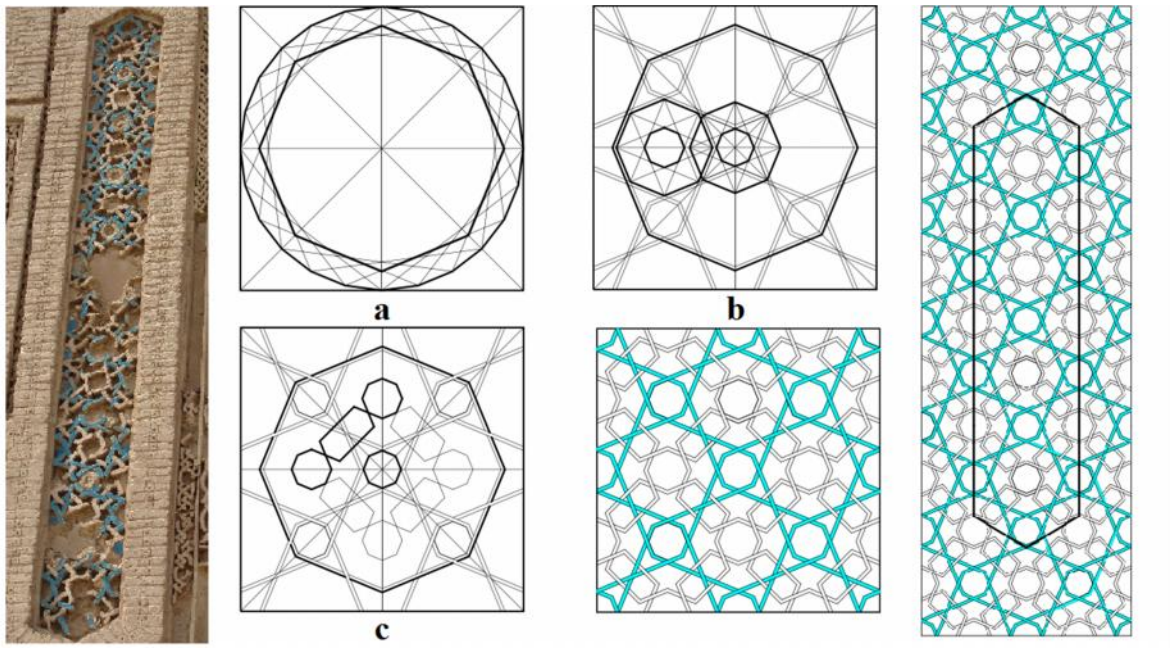

Figure 6: *Brickwork decorations in Malik-Zuzan mosque and the analysis of substructure.*

Malek Zuzan mosque is placed in the northeast of Iran. Based on the inscription, this building belongs to the 1211 AD [2]. The remained parts of brickwork decorations with glazed brick show a great innovation design of brickwork in this building. Two samples of brickwork decoration of this building are discussed in this paper. Figure 6 shows brickwork decorations on the northern iwan of this building. The probable method is suggested for drawing the substructure. As it is shown in the Figure 6 a, draw a tangent twenty four polygon inside a square and then connect every fifth vertex to each other. Like in the figure, an octagon is created by the intersections of these segments which are shown here in bold line. Now, transfer this octagon based on the squares vertices as well as the midpoints of its sides like in Figure 6 b. By doing so, the inside surface of the square is divided and produces regular frames for design. In the next step, two other octagons are drawn inside the first one. After that, connect every third vertex of these octagons to each other to find other octagons inside them. Based on Figure 6 c, the sides of these octagons are extended and decorative form is completed. At the end, the decorative strips are added to the patterns. The last square is the repetitive unit and the whole pattern can be completed by repeating this square unit based on its sides. The whole pattern in this figure was drawn beyond the main frame and the lines were passed from the boundary of the panel. This pattern follows *c2mm* type of symmetry groups.

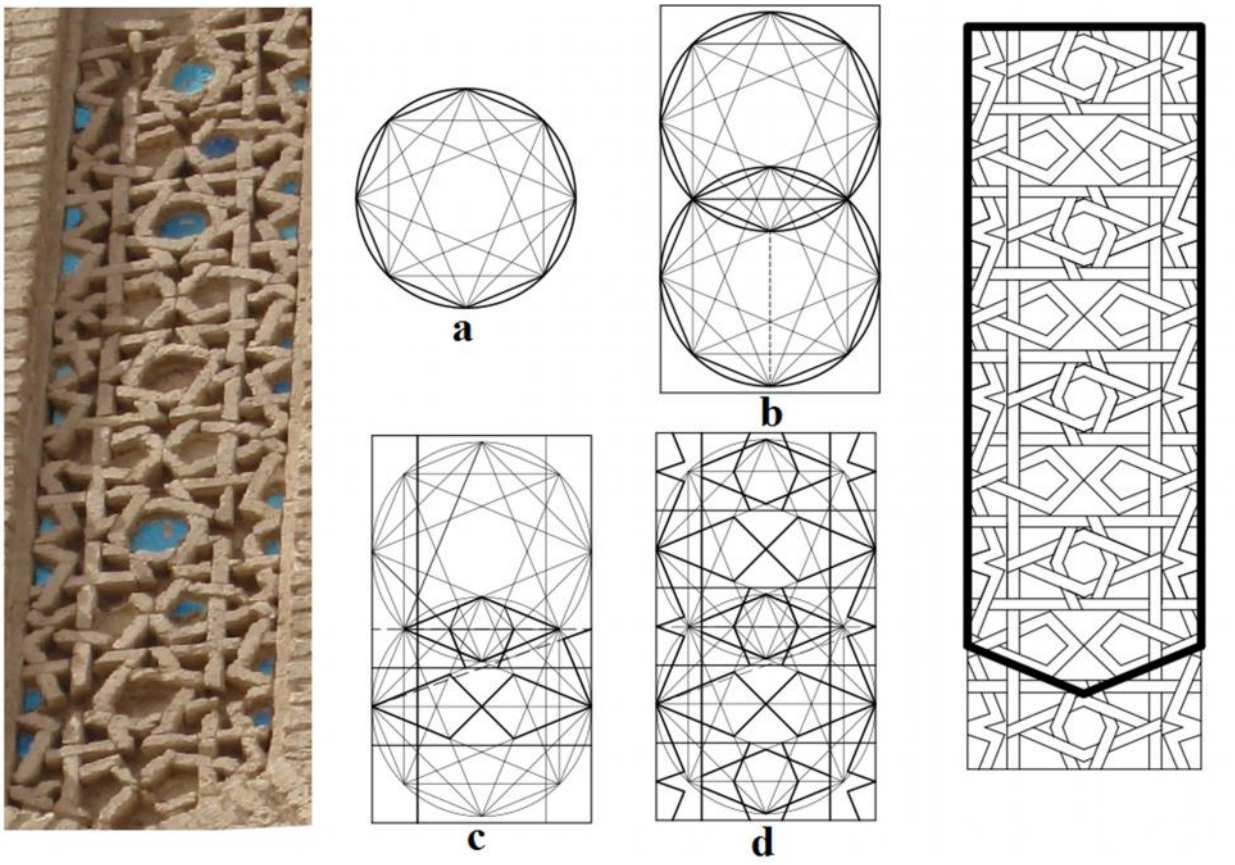

Figure 7: *Brickwork decorations in Malik-Zuzan mosque and the analysis of substructure.*

For depicting the substructure of the brickwork decoration in Figure 7, draw an octagon inside a circle at first and then connect every second vertex to each other and again connect every third vertex to each other. These steps are presented in Figure 7 a. Next, as in Figure 7 b, transfer the circle by the vector that is shown in dashed line. The frame of decorative design is also depicted by drawing two vertical lines

tangent to the circumference. Based on Figure 7 c, the main lines of the motifs can be extracted by the underlying lines obtained from the former steps. These lines are shown in bold in Figure 7 c. In Figure 7 d, a part of design is shown with its substructure lines. By repeating this unit the whole part of design can be created. This decorative brickwork was also drawn beyond the main frame and the lines were passed from the boundary of the panel. Thus, the main frame is shown by bold lines in Figure 7. This design has the symmetry type denoted *p2*.

Conclusion

By analyzing the brickwork decorations in this paper, the geometric substructures of their design have been extracted. In most of the examples, the substructures were drawn beyond the main frame and the appropriate parts of design were selected as the frame of brickwork decorations. The analyses demonstrate that various forms of symmetry and innovative usage of vector of transformation were applied in order to create the substructure of design, besides the accurate divisions of circles and polygons. Thus, it could be concluded from these analyses that the primary designs of these plaid grid brickworks were created with accurate geometrical substructures rather than based on plaid grids. These features in design of brickwork decorations, as the primary form of ornamental design in Iranian Islamic architecture, also reveal the knowledge of geometry applied by the craftsman in the early phases of decoration in Iranian Islamic architecture that had influence on creating complex geometric design in the subsequent centuries.

References

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