Muqarnas

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ABSTRACT
Muqarnas, which is one of the basic parts of traditional Islamic architecture and Islamic art, has its own important features in terms of usage areas. Although from the perspective of Islamic art history, Islamic architecture and Turkish-Islamic Architecture it is both a structural and artistic visual feast unfortunately not much work has been done on muqarnas. For this reason, the aim of this study is to eliminate this deficiency in the literature, in the light of the relevant literature, especially from the perspective of Fatih Uluengin's historic work titled "Stalactite Plans Trench" presented at the First Turkish Arts Congress (Ankara 19-24 October 1959). Issues regarding what a muqarnas is, where it is found and where it is used for will be questioned in this study.

KEYWORDS
Muqarnas, Decoration, Traditional Islamic Art, Islamic Geometric Patterns.

INTRODUCTION

In general terms, Muqarnas refers to a kind of console, stonework (or any material used to build them) protruding from a wall or ceiling, both used as a decorative element in Islamic architecture. The famous mathematician and astronomer Giyaseddin Çemşid, who lived in the 15th century, defined muqarnas in his work "Miftah al-Hisab" (Key to Arithmetic), in which he also included muqarnas arithmetic:

The muqarnas is a ceiling like a staircase with facets and a flat roof. Every facet intersects the adjacent one at either a right angle, or half a right angle, or their sum, or another than these two. The two facets can be thought of as standing on a plane parallel to the horizon. Above them is built either a flat surface, not parallel to the horizon, or two surfaces, either flat or curved, that constitute their roof. Both facets together with their roof are called one cell. Adjacent cells, which have their bases on one and the same surface parallel to the horizon, are called one-tier (DOLD- SAMPLONIUS, 1992).

Muqarnas is the gradual merging of patterns in Islamic geometric form (Figure 1) at the center point in 3D at a certain angle as a concave with the height and angle are given by the designer. Muqarnas is a decorative element protruding from a wall or ceiling, which is used as a decorative element in Islamic architecture, but in some geographies, it is used to lighten the load on the carrier. The muqarnas is in the form of small, pointed niches arranged in layers, each projecting forward from the level below (MÜLAYIM, 2006). Meanwhile, it is a design that uses a series of complex prism shapes resembling stalactites in some places where it is used. The stalactite element, which rises gradually with geometric calculations resembling stalactites, is defined as stalactite in Fatih Uluengin's (1959) works. In this respect, muqarnas is an architectural element that can spread the load of the dome to the carrier like a stalactite. The usage area and function of muqarnas vary according to the regions. In some regions, it is used as an ornament and embellishment.

Fatih Uluengin (1959) determined this situation in his article as follows; "This ditch ornament, whose origin we found in the Middle East, is found in various places such as crown doors, altars, domes, pendentives, squinches, balconies, corners, window jambs, etc." Muqarnas uses forms such as small niches, stars, that is, forms made up of Islamic geometric patterns (Figure 1).

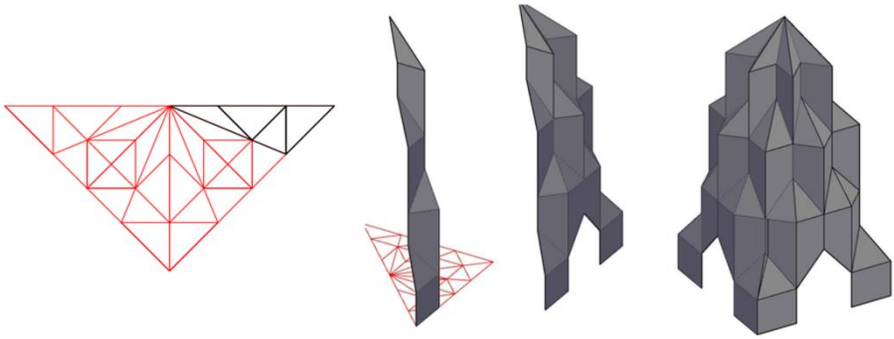

Figure 1: *Muqarnas on the Geometric Plan Consisting of an 8-Pointed Star and Divided into Two*

These geometric patterns are in a certain form and pattern, and these forms are arranged in layers, with a layer protruding forward from a lever below a certain level (Figure 2). This continues until it reaches a point and eventually forms an arch. They are generally applied on domes, pendentives, cornices, squinches, under arches and vaults, to fill the space under them. And with its honeycomb-like appearance in the transitions from the dome, it also displays a complementary intermediate material feature.

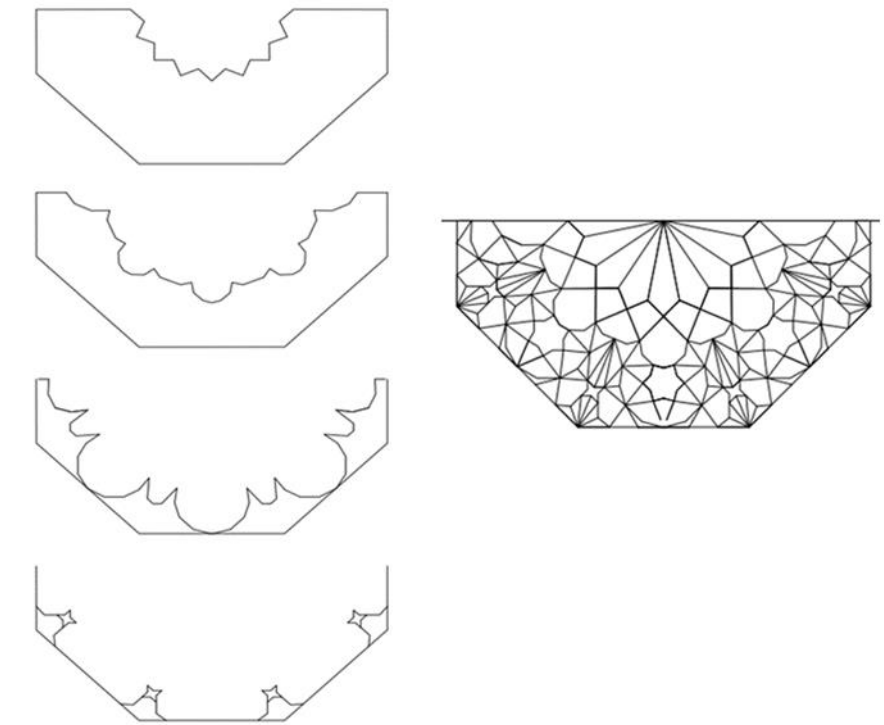

Figure 2: *The plan view of the muqarnas layers*

Muqarnas can be found on domes, columns, mihrabs, pendentives, honours, corners, column capitals, or window jambs (Figure 3). In summary, muqarnas, which elaborates and enriches many architectural elements in traditional Islamic arts, is one of the indispensable details of architectural works.

Figure 3: *Example of muqarnas in the carrier system and door of Sokullu Mehmet Pasha Mosque.*

All kinds of materials are used in the making of muqarnas. These materials have been shaped and diversified according to their usage areas. Muqarnas combinations are the transfer of geometric patterns applied as a plan into 3 dimensions (Figure 4). While geometric patterns spread to infinity with a certain system, they do not change at all, but only gain a third dimension over the same plan scheme (Figure 4). The patterns that progress in this geometrical order appear with the systematic layered dimensioning given to them, sometimes by spreading the load on the carrier, and sometimes by using them as an architectural decoration element (Figure 4). The three dimensions of the muqarnas used in Diyarbakir mosques are shown in (Figure 4). “Seven rows of muqarnas stalactites in the form of an eight-pointed star were placed in the area bounded by the frames.” (YILDIZ, 2011).

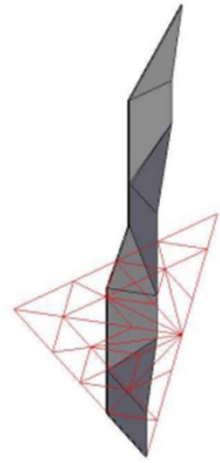

Figure 4: *Image of the muqarnas being moved to three dimensions on the plan.*

WHERE WAS MUQARNAS FOUND?

Muqarnas was introduced to the Iberian Peninsula by the Almohads in the 12th century, became famous as a "Moorish" and spread throughout the world, shaped in the identities of different geographies and survived to the present day, faithful to its original starting point (GLOSARIOARQUITECTONICO, N.D.). As the Islamic culture-expanded its borders across the world, it made itself felt through cultural interaction by taking its influence from the northern part of Africa to the western part of the European continent. Mathematics and geometry, which were quite advanced compared to medieval Europe, showed themselves in art with the developing culture. Muqarnas is mentioned in the work of al-Uzrî al-Endelüsî, known as Tarsiʿü'l Ehbâr, which is known to have been revealed between the years (1003-1085). In Miftahü'l Hisâb, muqarnas has been handled more artistically than its geometric design.

According to al-Kashi (N.D), a muqarnas consists of an edge and a surface. There is a roof that raises these edges like a ladder. And each edge is perpendicular to the adjacent edge, repeatedly perpendicular, or at half the angle of the right angle. Above these edges are one or two inclined surfaces

that are not parallel. In addition, the size of the largest side at the bottom is accepted as the size of the muqarnas.

According to al-Kashi (N.D), there are four types of muqarnas. These are "simple or biruminbar muqarnas (as the builder call it), mutayyan (muddy muqarnas), curved muqarnas and Shirazi muqarnas."

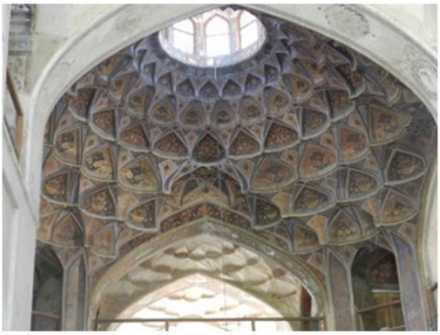

Figure 5: *Hasht Behesht Palace (8 Heavenly Palace), Isfahan*

WHERE IS MUQARNAS USED?

In both eastern and western muqarnas, the horizontal projection pattern acts as a solid template, in which muqarnas in one plane is made to match the next. Another interesting feature that makes muqarnas radically different from East and West is the degree of standardization. In the West, the muqarnas achieve some degree of complete standardization, no matter how complex the frieze or vault in question, we can be sure that the set is made of only eight different pieces. Each of these pieces is given a name and its shape has remained unchanged since Antiquity. In the East, on the contrary, although it is possible to recognize a number of individual parts, they can significantly change their shape to adapt to the desired design.

Figure 6: *Ali Qapu Palace (Left) and Jameh Mosque (Right) in Isfahan*

Figure 7: *Columns of Chehel Palace, Isfahan (Left) and Finnish Bath and Garden, Kashan (Right)*

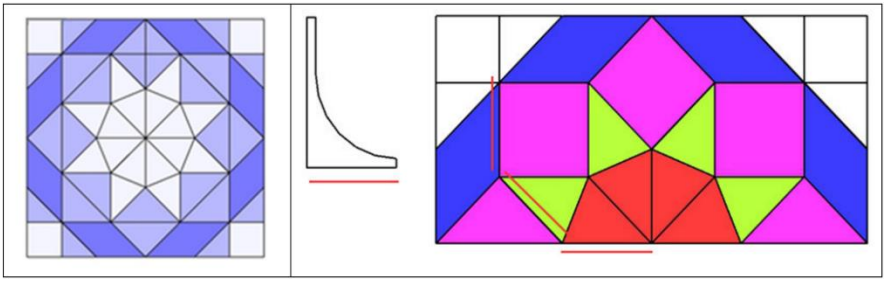

Figure 8: *Eight-pointed star divided into two parts in the middle*

First, it is divided into multiples to form a star muqarnas consisting of eight corners. By colouring each layer in a different colour, the layers that will be formed are understood. Thus, it becomes easier to understand and analyse muqarnas. Then, a "rib" is formed that will carry the muqarnas up and form the protrusions in the form of niches. This rib is the same size as the sides of triangles, squares, and equilateral.

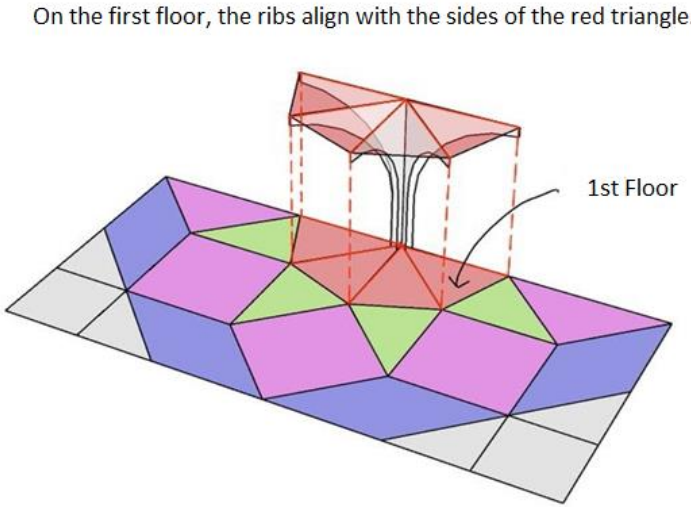

Figure 9: *Image of the ribs aligned parallel to the red triangle on the 1st floor*

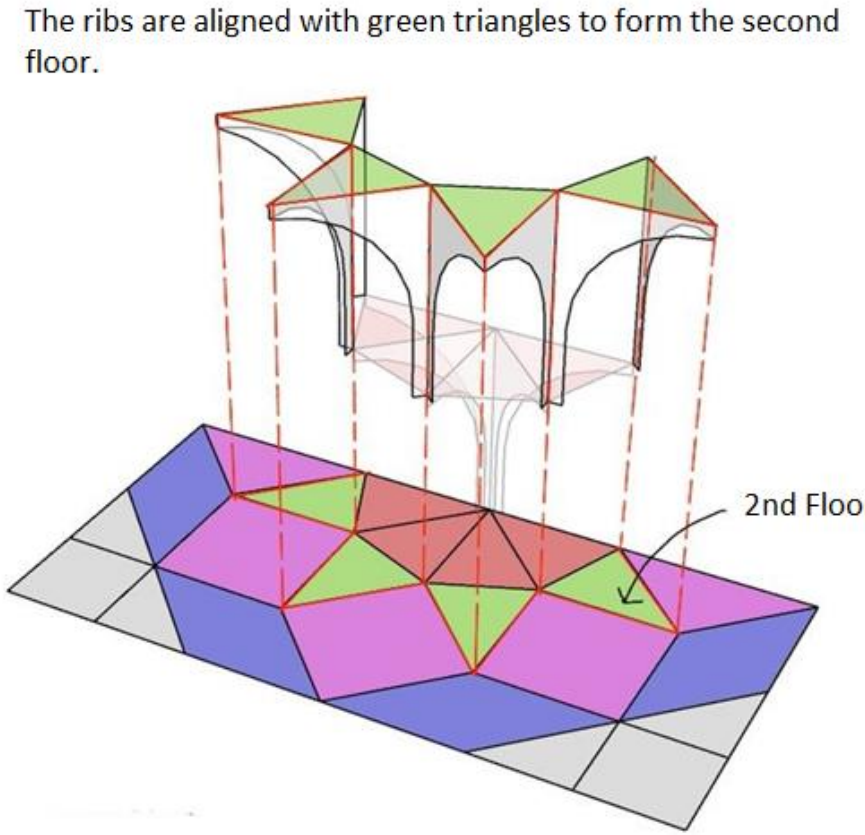

Figure 10: *Triangle alignment image of the upper surface of the ribs on the 2nd floor*

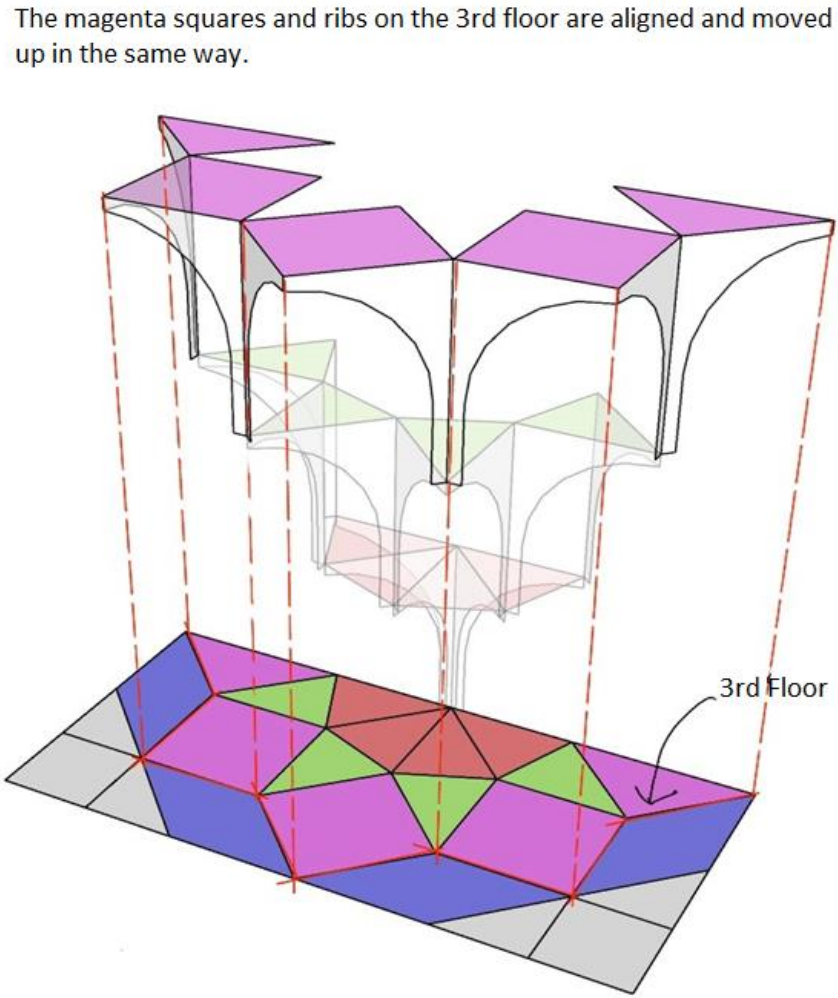

Figure 11: *Image of the alignment of the rib surface with the squares on the 3rd floor*

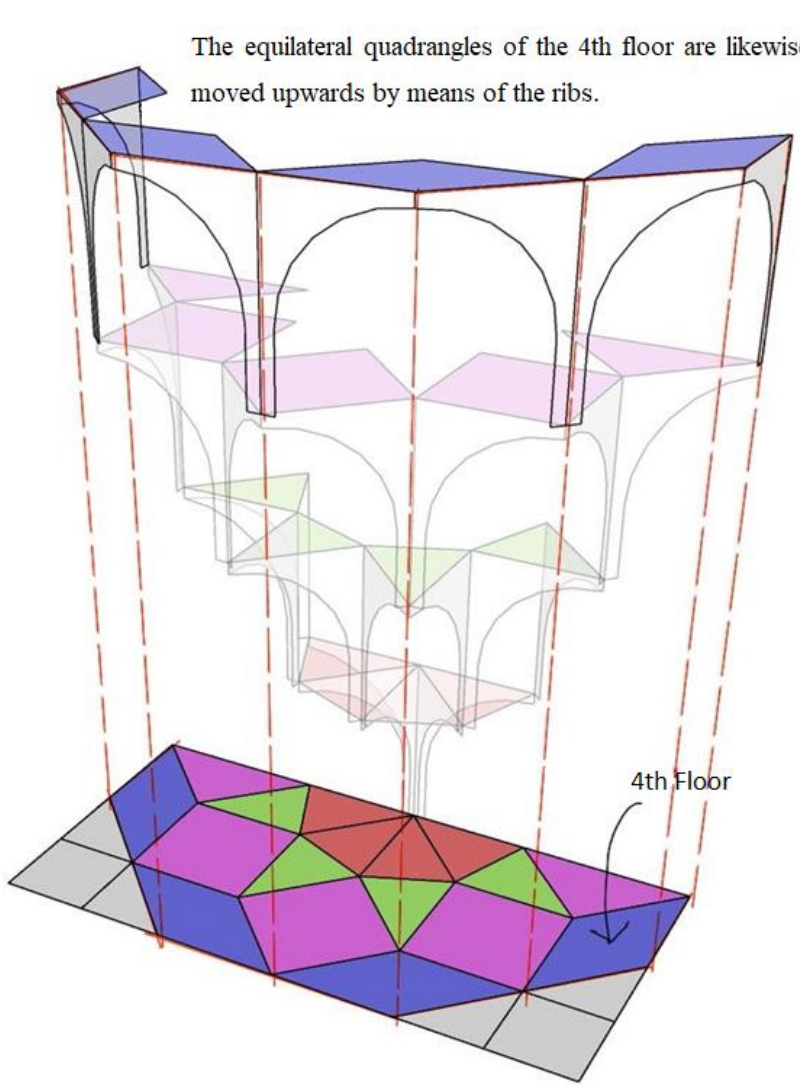

Figure 12: *Image of moving the rib surface upwards with equilaterals in the 4th floor*

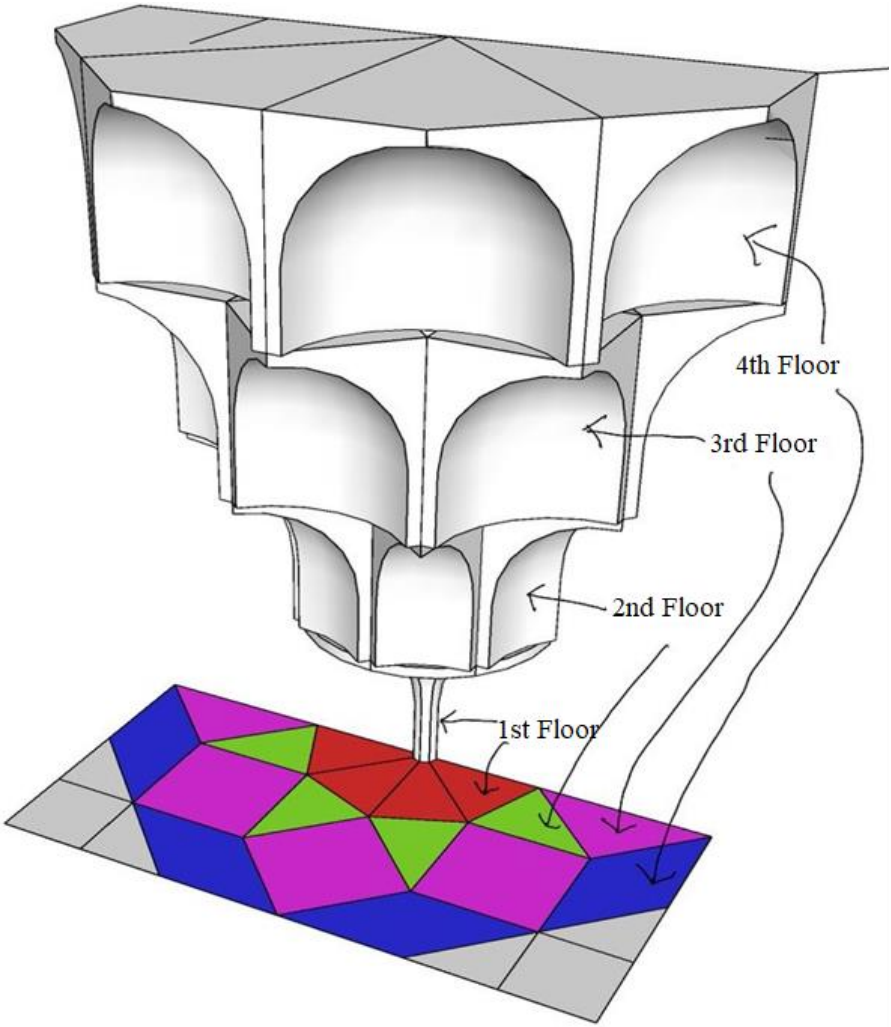

Figure 13: *Obtaining the final form by superimposing the muqarnas with the 1st, 2nd, 3rd, and 4th-floor levels*

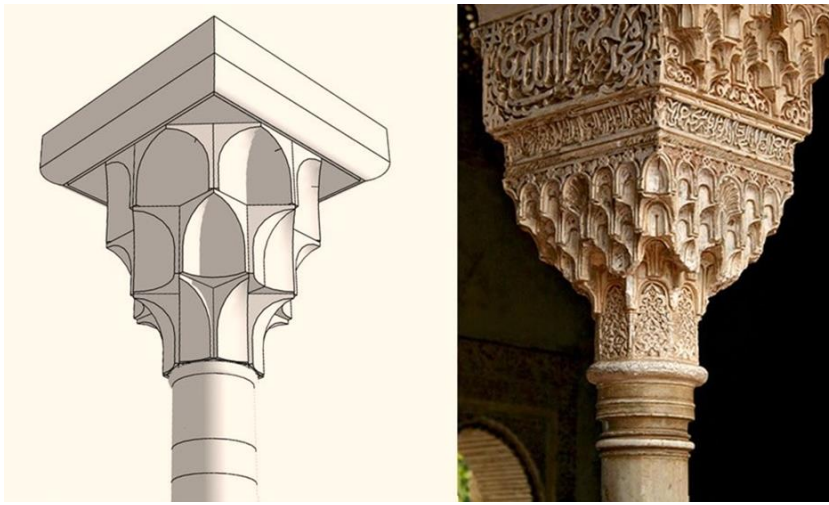

Figure 14: *The use of muqarnas created with an 8-pointed star*

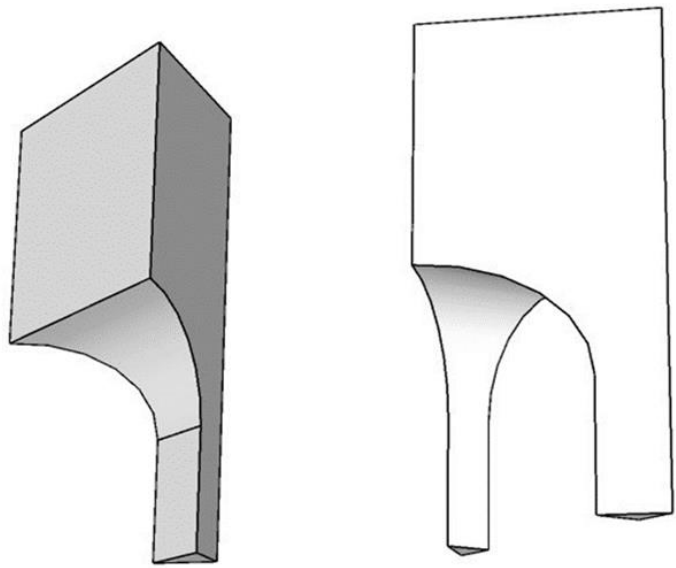

Figure 15: *Rib system consisting of two triangular prisms, one male and one female*

The ribs, which consist of two triangular prisms, one male and one female, are the system that staggers the layers of the muqarnas as convex or convex according to the starting point.

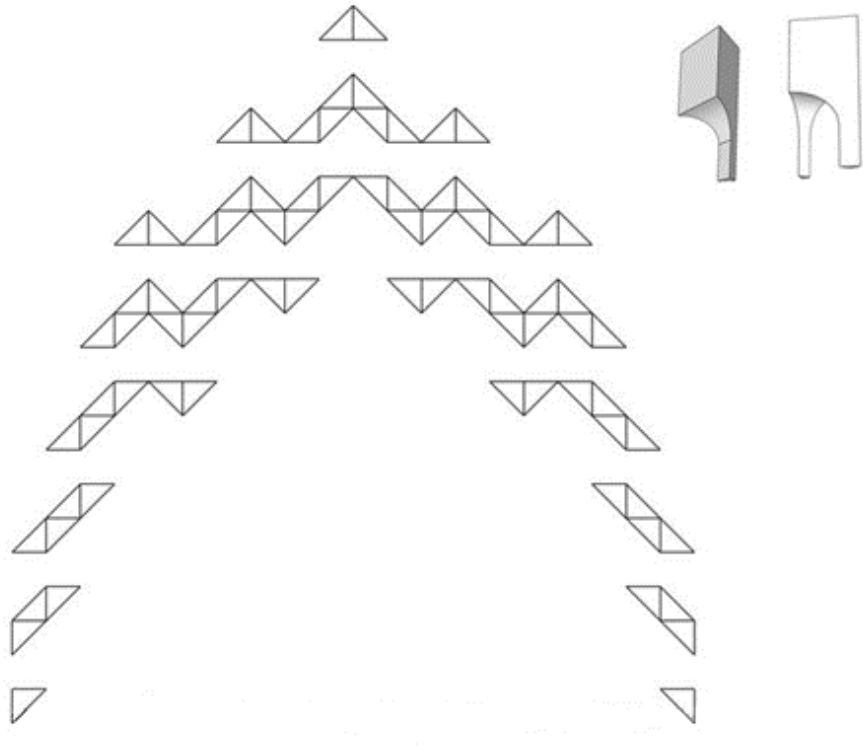

Figure 16: *Plan view of the triangular stalactite*

The setup here is prepared to create a 3-dimensional muqarnas, which will be made in 2 dimensions and will be seven layers based on triangles only.

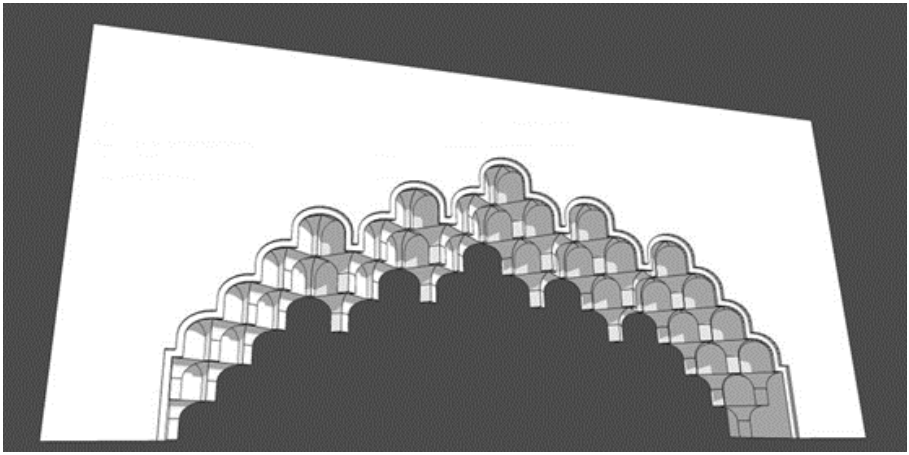

Figure 17: *Muqarnas form uncovered by forming layers with ribs from the triangular form*

As a result, a 7-story arch-shaped stalactite is formed from these triangles. The muqarnas, which are formed by the transition of 2-dimensional plans to 3 dimensional, are formed by grasping a surface of the geometry in a plan and pulling it upwards. While this feature does not change the plan, the height used on the surface is shaped according to the decision of the floor used or the architect.

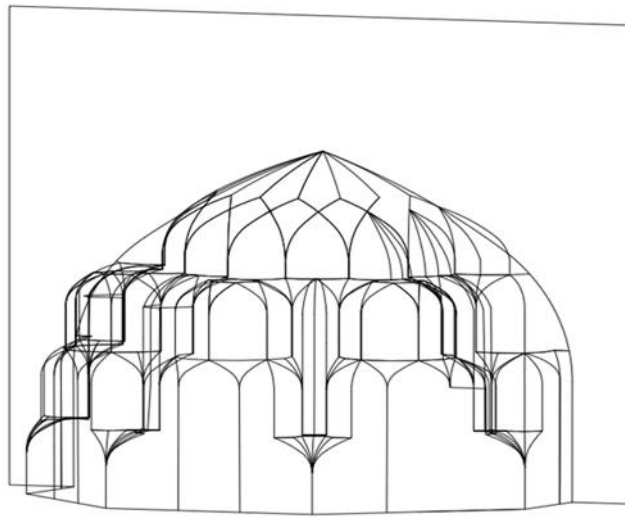

Figure 18: *Image of a stalactite sample made of a 12-pointed star*

Muqarnas differ according to the geographies in which they are used. So much so that as a result of the geometric analysis of the muqarnas, it can be distinguished from which culture they came from. This difference is due to the different angle techniques used when transferring the muqarnas from the main plan to different dimensions, rather than the geometrical diversification of the muqarnas. According to the expression of Fatih Uluengin, (1959) the angles used in different degrees provide diversity in dimensioning.

Figure 19: *Şah Gheragh Mosque in Şiraz (left) and Enah o Dolah Mosque in Kermanshah (right)*

While the geometric plan of the muqarnas in Iran, Central Asia, that is, orientalist cultural geography, continues in a certain order, in the same way, the stages are evident with the effect of the development of geometry in the Ottoman Empire. This situation can be clearly understood from the fact that the transitions used in the stages of the muqarnas layers in the advanced geometric system are made at different angles. The differences in these transitions show how the different geometric forms that are skilfully connected to each other are completed, even though they are transitions from different degrees of angles.

Interpretation of muqarnas with al-Kashi explains muqarnas more clearly as a bibliography. According to al-Kashi, they are the elements that connect cells and cell frameworks. In other words, the system that dimensions the geometry and connects the cells is very important. When the Stalactite Stars are analysed separately, it is seen that the ancestors had sufficient knowledge of these stars and geometric patterns in the past.

CONCLUSION

Understanding muqarnas directly can often be proportional to perspective. The muqarnas, which can be revealed in a system of its own with many polygons, brought a different dimension to the understanding of design. In Islamic architecture, where geometry is used as a design element, muqarnas is a design wonder that is created as a result of harmony, discipline, and a mathematical calculation in itself as a design element. Besides the use of geometry in plan, facade, and holistic sense in architecture, the use of computationally in detail elements is purely aesthetic. The connection established between the understanding of infinity in the design of geometry and reaching the supreme in the religion of Islam has passed into different dimensions in design.

The basic design elements in classical architecture have been moved to a traditional dimension with modern architecture. It is reinterpreted as parametric design in today's architecture. When traditional design approaches and parametric design are combined, design analysis has become more systematic with the use of new technologies. In order to understand the design of muqarnas, it is necessary to think in addition to embedding in 3D.

In the analysis of the muqarnas, first, the basic pattern that creates the muqarnas should be revealed, then the layers should be looked at by starting from this pattern. Single patterns from the same family form the main muqarnas design by providing a harmonious rule among themselves. That is, the regular rules between the patterns reveal the main pattern from different parts. All this harmony actually occurs as a result of a certain algorithm. In other words, in the design of muqarnas, all the basic principles of architecture are present. There is a non-symmetrical harmony as well as symmetry among themselves. It is a 3-dimensional parametric design created with a rhythm in the order of irregularity. Besides a certain rhythm, it provides continuity with an angle. It has a hierarchy within itself. It has a system that is complex most of the time but has simplicity in its own complexity. It is a mechanism where patterns that can take functions according to their places of use come together and provide continuity. In other words, while each pattern creates its integrity with a certain mathematical algorithm, each layer is associated with each other with a different parameter. Patterns harmonized in Fibonacci's Golden Ratio axis appear as reinterpreted in every design under the infinity emphasis of Islamic architecture.

When we look at the applications in parametric design, the methods followed, and the design stages reveal the beauty of the harmony between them. The parametric design provides an understanding of the design process. This creates a new perspective to understand the aesthetic understanding underlying the design. The systematic components that make up the muqarnas, the rules of the topological relationship and the main introduce parametric analysis. In other words, the analysis of the pattern becomes understandable with the rules of which system it is used. This improves the design knowledge. It reveals the concept in the main design. In this way, the basic composition in the design goes beyond the visible and becomes understandable. It easily explains the transition of the parameter to the software dimension. Of course, in this case, it is especially useful to remind that not only visual arts but also mathematics, astronomy, and physics contribute to today's design understanding by passing through a huge filter in muqarnas design. Finally, findings from current studies show that muqarnas like all architectural elements can be clearly rebuilt or new original muqarnas designs can be produced using parametric design tools.

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