THE HEXAGON FORM IN ISLAMIC ART

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Abstract- : Geometric ornamentation, one of the oldest aesthetic practices in human history, has been considered not only a visual organization tool but also a form of cosmological and symbolic representation in diverse cultures. After the adoption of Islam, this tradition merged with mathematical thought and Sufi interpretations, gaining a new aesthetic understanding. In this context, the hexagonal form has become a prominent geometric element in Islamic art due to both its mathematical precision and symbolic multilayeredness. This study examines the mathematical structure of the hexagonal form, its examples in nature, its symbolic meanings, and its use in tile decoration, particularly in the Seljuk and Ottoman periods. This review, based on a literature review, reveals that the hexagon has historically served not only as an aesthetic motif but also as a reflection of the principles of sanctity, order, and continuity within the holistic geometric language of Islamic art. Consequently, the hexagonal form, as a universal geometric motif in Islamic art, has played a central role in generating both visual richness and metaphysical meaning.

Index Terms- Islamic Art, Geometric Ornamentation, Hexagonal Form, Tile Decoration, Symbolism.

1 INTRODUCTION

Geometric ornamentation, one of the oldest aesthetic practices in human history, has functioned not only as a tool of visual organization but also as a symbolic expression of cosmological order across different civilizations. Since antiquity, basic forms such as circles, triangles, and polygons were employed both in architecture and decorative arts, establishing a close relationship between mathematical precision and aesthetic harmony. With the rise of Islam, this tradition acquired a new dimension: geometry came to be regarded not merely as a decorative element but as a visual language of sanctity, unity, and metaphysical order. The geometric repertoire of Islamic art is multilayered and can be interpreted simultaneously through mathematical principles and symbolic meanings (Çaycı, 2017, 58). Within this aesthetic system, the hexagon holds a particularly prominent position. Its regularity and capacity for infinite repetition allow for rhythmic continuity in surface decoration, while its symbolic associations emphasize harmony, balance, and perfection. Natural examples, such as honeycombs or crystalline structures, offered abstract models that inspired Islamic artists, who further transformed them into metaphysical and symbolic representations. British history professor Critchlow argues that Islamic geometry, by merging mathematical exactitude with Sufi thought, generated a visual language that reflects the perfection of divine order (Critchlow, 1976, 9). In this sense, the hexagon serves a dual function: as a natural form observable in the physical world and as a symbolic form pointing toward metaphysical and sacred realities.

From a historical perspective, the presence of the hexagonal form in Islamic art can be followed across diverse regions and periods. Early manifestations in Iran and Azerbaijan reveal its integration into geometric ornamentation, while in Anatolia the Seljuk and, later, the Ottoman dynasties elevated the motif through its

extensive use in tile decoration. In the Seljuk period, hexagonal arrangements were frequently employed in mihrabs, tomb façades, and madrasas, where mosaic tilework showcased both technical variety and aesthetic refinement. The Ottoman era further expanded this repertoire: monuments such as the Green Mosque in Bursa, the Karatay Madrasa in Konya, and the Topkapı Palace incorporated hexagonal designs into increasingly sophisticated decorative schemes, often interwoven with floral and vegetal patterns. This historical trajectory indicates that the hexagon functioned not only as a precise mathematical figure but also as a cultural and symbolic motif deeply embedded within the visual identity of Islamic art.

The purpose of this study is to investigate the hexagonal form in Islamic art from a multidimensional perspective. The analysis first addresses its mathematical principles and natural analogies, then considers its symbolic and cosmological implications, and finally examines its role in tile decoration during the Seljuk and Ottoman periods. Through this approach, the study aims to show that the hexagon, beyond its ornamental role, embodies essential metaphysical and cultural values central to the aesthetic language of Islam.

1.1 SCOPE OF THE RESEARCH

The main objective of this study is to provide a comprehensive examination of the hexagonal form in Islamic art by addressing its mathematical, symbolic, and aesthetic dimensions. The hexagon, with its regular structure and capacity for infinite repetition, transcends the status of a simple geometric figure and acquires cosmological and metaphysical meanings, particularly within the Islamic cultural context. Natural examples, such as honeycombs or crystalline structures, have inspired Islamic artists, who transformed the form into an abstract visual language enriched with both aesthetic and symbolic significance. This research covers three key dimensions. First, the mathematical properties of the hexagon and its place within geometry are discussed. Second, its symbolic and cosmological interpretations are analyzed in light of natural analogies. Finally, examples from Seljuk and Ottoman tilework are examined to demonstrate the role of the hexagon in architectural decoration. Through this approach, the study aims to show that the hexagonal form is not merely a decorative motif, but a central symbol that conveys the holistic aesthetic and metaphysical values of Islamic art.

1.2 METHODOLOGY

This research adopts an analytical approach based on an extensive review of the literature. Primary and secondary sources in both Turkish and foreign languages concerning Islamic geometric ornamentation, symbolism, and tile decoration have been examined, with particular emphasis on studies addressing the hexagonal form. These materials were comparatively evaluated in order to build a coherent framework for analysis. The theoretical foundation of the study is based on three key works: Ahmet Çaycı's *İslam Mimarisinde Anlam ve Sembol* (2017), which investigates the symbolic dimensions of Islamic architecture and geometry; Keith Critchlow's *Islamic Patterns (*1976), which analyzes the mathematical and cosmological basis of geometric designs; and Selçuk Mülayim's *"Geometric Ornaments in Anatolian Turkish Architecture* (1982), which provides a chronological and technical examination of geometric ornamentation in Anatolian Seljuk architecture. Alongside these core references, additional articles and theses have been consulted to enrich the analysis and contextualize the historical and symbolic functions of the hexagon in Islamic art.

2 ISLAMIC ART AND GEOMETRY

Geometric ornamentation has evolved throughout human history, reflecting the cultural, geographical, and intellectual trajectories of different civilizations. The progress of mathematics and geometry has been inseparable from their applications in the decorative arts, where both disciplines found aesthetic and philosophical expression (Critchlow, 1976, 6-7). In particular, ancient approaches frequently employed mathematics and geometry as intellectual instruments to provide a concrete explanation of nature and the universe, and over time, geometry evolved beyond a mere mathematical tool to become a philosophical method for interpreting the fundamental structure of the cosmos. Under the influence of early philosophical traditions, such as those of Pythagoras and Plato, geometry came to represent the divine order underlying the universe—a

notion later inherited and reinterpreted within the Islamic intellectual world (Zarepour, 2022, 198). This accumulated knowledge, developed throughout history, was also carried over into the realm of Islamic science and art, embodying innovations. The understanding of geometric ornamentation in Islamic art was informed by the pre-Islamic accumulation of geometric decorative art used in regions such as Egypt, India, Iran, Greece, Rome, and China, as well as being influenced by Hermetic, Orphic, and Gnostic approaches.

The etymology of the term geometry itself derives from the Greek “geo” (earth) and “metron” (measurement), implying the act of measuring and structuring the world. Conceptually, geometry functions as a process of delimitation on the micro scale that mirrors the macrocosmic harmony of nature. As Çaycı this emphasizes, “Islamic art may fundamentally be defined through the formation of a geometric repertoire” (Çaycı, 2017, 58). This observation underscores that geometry and Islamic art are intrinsically inseparable. In architectural and decorative contexts, geometric delimitations are achieved through the repetition and interlacing of basic shapes—circles, triangles, squares, hexagons, and octagons—resulting in dynamic compositions of infinite extension (Mülayim, 1982, 70). Through linear repetition—whether of curved, broken, or straight lines—artists generate new visual harmonies and symbolic meanings, reflecting the unity, rhythm, and transcendence at the heart of Islamic aesthetics.

First, the technical and material traditions inherited from earlier civilizations—such as those of Egypt, Persia, and Byzantium—provided the foundational framework for geometric expression in Islamic art. By the 11th century, particularly in regions such as Syria, Egypt, and Iran, these inherited traditions evolved into distinctive regional styles characterized by increasingly sophisticated geometric configurations (El-Said & Parman, 1976, 1). Early monuments, including the Great Mosque of Damascus, reveal transitional phases in which floral motifs coexist with geometric structures, signaling the gradual emergence of a distinct decorative language (Fig. 1&2). During the Karakhanid and especially the Great Seljuk periods, geometric compositions achieved both structural coherence and conceptual autonomy, becoming a defining visual idiom of Islamic architectural ornamentation (Mülayim, 1982, p. 70).

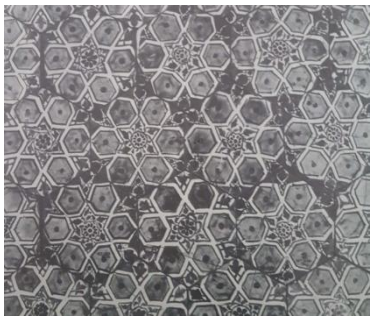

Figure 1: Great Mosque of Damascus (715 AD- 715 CE), Hexagon Tiles, (El-Said, & Parman, 1976, 144).

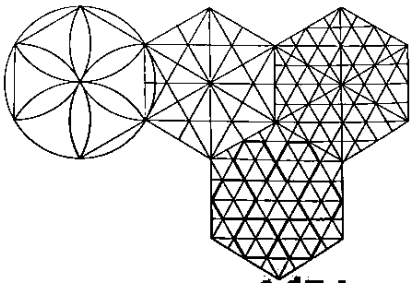

Figure 2: Great Mosque of Damascus, Hexagonal Tile Compositions, (El-Said, & Parman, 1976, 144).

A second explanatory dimension relates to the theological and aesthetic implications of aniconism—the deliberate avoidance of figural representation—which prompted artists to explore abstraction and mathematical harmony as alternative means of visual expression. The intrinsic properties of materials such as brick, tile, and plaster further encouraged modular repetition and precise geometric design, thereby reinforcing the aesthetic of abstraction (Demiriz, 2000, 24).

Finally, from a metaphysical standpoint, Sufi philosophy articulated a profound correspondence between geometry and divine perfection. Within this intellectual framework, geometric order was conceived as a mirror of the immutable harmony of creation—an echo of God's infinite, measured, and harmonious essence. As a result, the precise and proportionate laws of geometry transcended their decorative function, becoming visual manifestations of spiritual truth and cosmic equilibrium. In this regard, geometric ornamentation in Islamic art surpasses mere aesthetic purpose; it operates as a visual theology that renders metaphysical concepts into mathematical form, uniting faith, intellect, and beauty within a coherent artistic system.

3 A GENERAL OVERVIEW OF THE HEXAGONAL FORM

The hexagon, a universal form, has not only been a fundamental element of mathematics and geometry in terms of its formation and structural use, but it has also appeared throughout human history in philosophy, religious symbolism, cosmology, and astronomy. The enduring presence of this form across cultures reflects humanity's attempt to comprehend the underlying order of nature through geometry. Indeed, the profound influence of geometric forms on human civilization is itself rooted in the natural world, where patterns such as honeycombs, snowflakes, and crystal structures exemplify perfect hexagonal symmetry. In Islamic art, this intrinsic link between geometry and nature manifests through a visual language that mirrors cosmic harmony and order, as "geometric design in Islamic art stressed the importance of unity and order" (The Metropolitan Museum of Art, 2001, p. 1).

3.1 MATHEMATICS OF THE HEXAGON

The regular hexagon, a form frequently employed in Islamic art and observed across numerous architectural and decorative examples, embodies both geometric precision and mathematical harmony. It is defined as a polygon consisting of six equal sides and six congruent interior angles, each measuring 120°. The sum of its interior angles can be expressed by the general formula for polygons, $(n - 2) \times 180°$, where n represents the number of sides; thus, for a hexagon, the total equals 720°.

From a technical perspective, the construction of a regular hexagon is rooted in the principles of geometric proportionality and symmetry. The process begins by drawing a horizontal base line and determining its midpoint, which serves as the diameter of a reference circle. Using this radius, a circle is drawn; from a point on

its circumference, a second circle of equal radius is constructed. The intersection of these two circles marks a new center, from which additional circles—each sharing the same radius—are successively generated. When six outer circles are arranged symmetrically around the central one, the resulting configuration resembles a floral motif. By connecting the points of intersection among these peripheral circles with three primary axes—one vertical and two diagonals—all passing through the central diameter, the vertices of the regular hexagon emerge naturally (Fig. 3). Connecting these intersection points completes the figure, revealing the underlying mathematical logic that unites natural symmetry, geometric order, and artistic proportion.

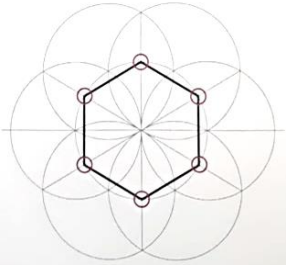

Figure 3: Hexagon Drawing, (Broug, 2008, 14).

3.2 RELATIONSHIP OF THE HEXAGON WITH OTHER GEOMETRIC FORMS

A movement, object, or concept—when identifiable—must represent a point of origin for both the phenomenon itself and the consciousness perceiving its emergence. Within the human mind, this origin signifies undivided awareness; in the material world, it corresponds to the uninterrupted focal point of events. Symbolically, the point expresses the primal state of existence, the seed from which all form unfolds. The spermatozoon, representing the first stage of human life, embodies this principle through its reduction to a single, indivisible point—a moment where creation begins. Human existence, which commences from a point and ultimately returns to it, thus reflects a cyclical ontological structure. All forms originate from a single point of unity—the center—from which the diversity of creation unfolds and expands (Critchlow, 1976, 9).

In physical terms, a point has neither area nor volume; it is a central expression of presence. Yet, through its relation to other points, it extends infinitely, generating line, plane, and volume—the fundamental stages of geometric realization. The hexagon arises precisely through this relational logic, formed by the systematic connection of points and lines. It integrates not only linear but also planar geometries such as circles and triangles, which influence both its formation and its symbolic interpretation. Across civilizations, these elementary forms have acquired cosmological and spiritual meanings, granting the hexagon its universal significance.

As Hesar (2014) explains, *"Sacred geometry in Islamic architecture reveals the harmony between natural order and divine unity, where geometric forms—circles, triangles, and hexagons—symbolize the hierarchy of existence and the manifestation of perfection"* (Hesar, 2014, 3806). In mathematical construction, the regular hexagon emerges through the intersection of seven equally sized circles—one central and six surrounding—forming a composition that visually recalls the order of nature. Considering the intersecting zones and connecting points of the central circle, the hexagon can be divided into six rhombuses or twelve right-angled triangles (30°, 60°, 90°), whose internal relationships determine its perimeter and area .The presence of these interlocking triangles reinforces the proportional and modular logic that lies at the heart of both geometry and Islamic artistic thought.

3.3 HEXAGON IN NATURE

The term nature originates from the Latin natura, meaning "to be born"(Lawrol, 1982, 24). As Heraclitus famously remarked, "Nature loves to conceal," a statement that may also be interpreted as the concealment of

the principles underlying existence (Critchlow, 2011, 26). Within this philosophical framework, the geometry of nature encapsulates the order of the universe, linking all living beings within a unified cosmic system. Geometry thus represents both a condition of existence and a manifestation of the measurable limits of universal space. Humanity, inspired by natural structures, has continually translated the logic of geometry into architecture, art, and the design of functional objects, blending imagination with mathematical order.

Figure 4: The Intersection Point Of The Hexagonal Stem And Flower Base Of The Narcissus Flower, (Critchlow, 2011, 26).

Figure 5: The Internal Structure Of A Daisy In A Hexagonal Shape ,(Critchlow, 2011, 230).

Iamblichus expressed this relationship succinctly when he wrote that "Nature expresses invisible causes through visible forms"—revealing how natural geometries serve as tangible reflections of hidden generative forces (Iamblichus, 1821, 284). Among these geometries, the hexagon stands as one of the most pervasive and efficient forms observed in the natural world. This six-sided configuration appears across scales, from macroscopic floral structures to microscopic crystalline arrangements.

For example, the corolla of the narcissus flower often displays a hexagonal symmetry, and the junction between its stem and receptacle forms a regular hexagonal pattern (Fig. 4). The honeycomb, perhaps the most iconic instance of this geometry, exemplifies natural precision and structural economy. Bees construct their hives using perfectly regular hexagons because this configuration requires the minimal amount of wax while maximizing storage capacity, thereby ensuring material efficiency and spatial stability. Likewise, the seed-bearing carpel of the daisy reveals hexagonal arrangements following spiral growth patterns (Çaycı, 2017, 56) (Fig. 5). On a molecular scale, snow crystals—composed of water molecules arranged in sixfold symmetry—demonstrate the same geometric order in an invisible yet fundamental form.

3.4 HEXAGON'S COSMOLOGICAL AND SYMBOLIC MEANINGS

The hexagon, as a geometric configuration, encompasses the point, line, and triangle—fundamental planar elements that constitute the foundation of all geometric forms. When combined with circles and star patterns, it acquires additional layers of symbolic meaning that have evolved through various historical and cultural

contexts. Across civilizations—including Islamic, Hermetic, Judaic, and Indian traditions—the hexagon has consistently functioned as a mediator between geometry and metaphysical symbolism.

In Islamic cosmology, the number six holds particular theological significance. The Qur'an states that Allah created the heavens and the earth in six days, as mentioned in Surah Al-A'raf (7:54) and Surah Yunus (10:3) (Çoruhlu, 2002, 201). This correspondence between divine creation and the sixfold structure of the hexagon reinforces the symbolic relationship between geometry and sacred order. The completion of the hexagon by the encompassing circle further deepens this symbolism: the circle represents the celestial and infinite, while the hexagon—emerging from its division into six equal parts—embodies harmony, balance, and perfection. In this sense, the circular–hexagonal relationship visually manifests the principle of unity within multiplicity, echoing the geometric logic of the Golden Ratio.

Throughout history, the hexagon has appeared at the core of the six-pointed star, which has become one of humanity's most enduring symbols. In the seventeenth century, Jewish communities adopted this figure—known as the Shield of David or Magen David—as an emblem of divine protection and spiritual power. By the nineteenth century, under the influence of Theodor Herzl, it was institutionalized as the modern symbol of Judaism. The star, formed by the intersection of two equilateral triangles, conveys the duality and interdependence of masculine and feminine forces, symbolizing the union of heaven and earth and the creative balance between opposites (Wilkinson , 2011, 22).In Islamic tradition, the same six-pointed configuration is known as the Seal of Solomon (Mühr-i Süleyman), a powerful talismanic emblem deeply embedded in Turkish architectural and artistic heritage. According to related legends, the Seal of Solomon granted the prophet supernatural wisdom and authority, allowing him to communicate with spiritual beings and maintain cosmic justice (Fig. 6). Consequently, the seal functions as both a divine emblem of balance and an apotropaic symbol believed to guard against evil forces—an intersection where geometry, faith, and metaphysics converge.

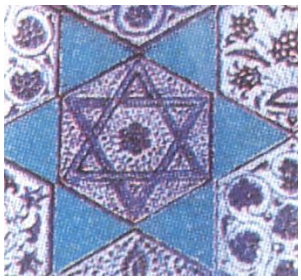

Figure 6: Muradiye Mosque in Edirne (1435), Seal of Solomon On Hexagonal Ceramic Tile, (Türeli, 2011, 45).

The six-pointed star, as previously discussed, also occupies a significant place within the Hermetic tradition. In Hermetic philosophy, this figure—composed of two interlocking equilateral triangles, one oriented upward and the other downward—symbolizes the macrocosm, the totality of the universe (Critchlow, 2011, 105). This geometric form embodies the principle of the union between opposing forces: spirit and matter, heaven and earth, or the active and passive elements of creation.

In alchemical and astrological contexts, the same star carries complex symbolic associations. It has been interpreted as representing the correspondence between the seven classical planets and the seven elemental metals. Within this schema, the Moon (silver) is positioned at the upper point, Saturn (lead) at the lower, Venus (copper) on the upper right, Mercury (quicksilver) on the lower right, Mars (iron) on the lower left, and Jupiter (tin) on the upper left, with the Sun (gold) occupying the center (Türeli, 2011, 75). The solar center thus signifies the culmination of transformation—the alchemical perfection whereby the base metals are transmuted into gold, symbolizing enlightenment and spiritual completion.

A parallel interpretation appears in Indian cosmological symbolism. In this context, the interpenetration of two triangles represents the creative and destructive principles of the universe: the upward-facing triangle corresponds to Vishnu, the sustainer or creator, while the downward-facing triangle corresponds to Shiva, the destroyer and transformer. Their intersection, forming the six-pointed star, signifies the dynamic equilibrium between generation and dissolution, a recurring theme in Hindu metaphysics (Eliade, 1958, pp. 78–80).

4 HEXAGON PATTERN DESIGN

To comprehend the significance of geometric ornamentation and its role within Islamic art, it is essential first to consider the theological and aesthetic principles established by Islam. Foremost among these is the prohibition of figural representation, a directive that profoundly shaped the visual vocabulary of Islamic culture. Under the influence of this principle, artists and craftsmen were compelled to adhere to specific design conventions that emphasized abstraction, repetition, and mathematical precision. As a result, geometric and floral ornamentation became dominant modes of artistic expression, reflecting both spiritual restraint and creative ingenuity.

Islam's restrictions on the depiction of living beings did not inhibit artistic development; rather, they fostered innovation within the permissible domains of design. This constraint led to the refinement of geometric and vegetal systems, giving rise to extraordinary diversity among artisans who specialized in particular materials and media. One of the defining characteristics of Islamic geometric design is its generative capacity—the ability to produce infinite variations from minimal structural changes. Within the geometric decorative arts, several fundamental compositional principles emerged. The first is the principle of infinite repetition, observable in surface-covering patterns that can be extended endlessly, symbolizing the boundlessness of divine creation. The second is the principle of symmetry, employed to achieve visual harmony and balance. A third and equally significant feature is the principle of anonymity: with the exception of a few renowned architects such as Mimar Sinan, the identities of the craftsmen responsible for works in brick, stone, tile, stucco, and wood generally remain unknown. While geometric ornamentation varied across time, region, and medium, it consistently exhibited formal coherence and technical sophistication. The evolution of materials and methods—ranging from brick and glazed tile to carved stone and wood—produced regional variations and distinct stylistic schools. In the earliest Islamic monuments, brick served as the primary material for geometric compositions; in subsequent periods, the introduction of tilework expanded both the chromatic and structural possibilities of ornamentation. Depending on the historical context, geometric motifs alternated between serving as dominant decorative frameworks and functioning as complementary elements alongside vegetal arabesques and rumi scrolls. This continuous interplay between material, technique, and form illustrates the adaptability of geometric aesthetics within the broader trajectory of Islamic art.

When examining composition in Islamic countries, there are no written documents explaining geometric rules. Geometric arrangements were calculated and implemented using known drawing techniques such as enlargement and reduction. The field we are interested in, which discusses geometric shapes and the relationships between them, is "plane geometry." Plane geometry, with its axioms and postulates that provide the mathematical reality of lines valid for flat surfaces (paper, etc.), connects all kinds of fundamental elements to solid foundations (Mülayim, 1982, 69). Although geometric compositions used for decoration are not limited to paper, they are fundamentally composed of points, lines, and arcs. The symmetrical formations created by shifting shapes relative to an axis or point constitute geometric compositions. Forms such as triangles, quadrilaterals, hexagons, octagons, and so on, formed geometric compositions. All geometric compositions can be grouped into infinite borders and central groups based on their analytical structures and formal characteristics. These centrally characterized compositions are, in fact, closed systems, drawn from an infinite composition and prevented from spreading or opening up (Mülayim, 1982, 70). owever, as is well known, architectural surfaces cannot extend to infinity, so infinite compositions are limited to finite surfaces. When examined, the hexagonal form, known as a geometric composition element, attracts attention with its diverse and distinctive compositions in tile applications in Islamic art.

4.1 HEXAGON TILES IN ISLAMIC ART

The origins of geometric ornamentation are generally traced back to the Upper Palaeolithic period. From this era onward, early instances of triangular, hexagonal, and spiral motifs—forms that would later serve as the foundations of geometric pattern design—began to appear. Such ornamentation is documented within prehistoric cultures of the Near East and Anatolia, where abstract and repetitive designs first emerged as expressions of symbolic thought. Although the historical trajectory of these motifs exhibits certain discontinuities, the essential geometric vocabulary persisted and evolved, eventually attaining new significance within the artistic language of Islam. To understand the development of geometric ornamentation in Islamic architecture, it is necessary to consider the broad geographical and cultural environments in which Islam arose and expanded. Islamic geometric design embodies both the inherited aesthetic sensibilities of ancient civilizations and their reinterpretation within a new religious and philosophical framework. The ornamental repertoire of Islamic art bears clear traces of earlier traditions—including those of Egypt, India, Persia, Rome, and China—whose visual systems contributed to a cumulative synthesis of geometric knowledge. This synthesis was rearticulated in simplified yet coherent forms in pre-Islamic Syria, providing a visual foundation for later Islamic architectural expression. The earliest and most celebrated example of this synthesis is found in the Great Mosque of Damascus (completed in 715 CE), where pre-Islamic artistic traditions were harmoniously integrated into a distinctly Islamic decorative program.

In the early stages of Islamic art, specifically during its formative period in Syria, the influence of distinctly Islamic characteristics remained limited when compared to the enduring legacies of Hellenistic and Sassanid traditions. Consequently, Syria produced the earliest and most significant examples of geometric decorative culture within the Islamic visual sphere. Early Islamic geometric ornamentation—most notably the incorporation of circular and hexagonal motifs executed in brick—can be observed in monuments such as the Mosque of Ibn Tulun (789 CE) in Cairo, which exemplifies the transition from pre-Islamic construction aesthetics to a distinctly Islamic decorative syntax. Similarly, geometric compositions had already become a dominant visual principle in Persia during the Sassanid period, where the emphasis on structural order and rhythmic repetition foreshadowed later Islamic developments. Initially, the Abbasid use of adobe and unglazed brick techniques laid the groundwork for subsequent experimentation. These were later refined through the introduction of fired and glazed brick methods, which allowed for greater chromatic and textural variety. The revival and systematic development of geometric composition in Persia emerged under the Seljuks, marking a decisive phase in the evolution of Islamic architectural ornamentation. By the late tenth century, artisans began to combine Central Asian bare-brick construction techniques with the emerging use of mosaic tilework, establishing the formal and material vocabulary that would characterize Islamic architecture across the medieval Persianate world (Mülayim, 1982, 17).

The mosaic tile technique involves the preparation of pre-fired tiles coated with colored glaze, upon which the desired patterns are applied. These tiles are then cut according to the compositional design, with their backs shaped into a conical form to facilitate setting. The prepared pieces are inverted and arranged face-down, after which mortar is poured over them to create cohesive tile panels. Once dried, these block-like panels are assembled onto architectural surfaces in varying scales of repetition.From a historical perspective, the earliest known example of interlaced geometric mosaic tilework in Islamic architecture is the Kümbet-i Surh (Red Dome) in Azerbaijan, dated to 1147. Another notable monument, the Mümine Hatun Tomb in Nakhchivan, Azerbaijan, features compositions that integrate both brick and mosaic tile fragments—including hexagonal, five-pointed, and eight-pointed star motifs—though the mosaic tiles in this case are specifically positioned within the eight-pointed stars. A later and more advanced example can be observed in the Gök Masjid (Blue Mosque) of Tabriz (1465), which contains mosaic tiles arranged in three distinct six-pointed star configurations. Similarly, in the Masjid al-Jami of Varzaneh in Iran—whose construction began in the ninth century and continued through the fifteenth century—mosaic tile applications reveal hexagonal arrangements and six-

pointed star compositions (Fig. 7). This enduring geometric vocabulary, adapted and refined across centuries, exemplifies the evolution of tile techniques in Islamic architectural ornamentation.

Figure 7: Iran (Varzaneh) Masjid al-Mosaic Mosque (8th Century), Mosaic Tile Application(El-Said & Parman 1976, 74).

4.2 HEXAGON IN TURKISH TILE ART

Historically, the first examples of geometric ornamentation were introduced into Anatolia following the arrival of the Turks in the eleventh century. By the twelfth century, the employment of glazed tiles and worked stone had become increasingly prevalent in architectural structures. In Anatolia tile-decoration techniques were generally applied to interior surfaces of buildings and only to a lesser extent to their exteriors (Mülayim, 1982, 51). The rise of tile decoration was influenced by the decline in the use of brick in compositions in the art of the Great Seljuk Empire of Iran. The most significant difference between tiles and bricks in this regard is their colorful and vibrant appearance, allowing them to distinguish the background, edge, and corner areas of architectural compositions. Turquoise, cobalt, and purple are frequently seen in the color spectrum. Mosaic tile examples are particularly visible in civil and religious structures in Konya, Sivas, and Kayseri.

Historically, one of the earliest examples of mosaic tile usage in Anatolia can be observed in the Siirt Ulu Mosque, constructed in 1129, which features a hexagonal star-shaped mihrab made of mosaic tiles. This represents one of the first deliberate applications of mosaic tiles in Anatolian Islamic architecture. A subsequent and more comprehensive use of mosaic tiles is seen in the Divriği Kale Mosque, erected by the Mengüçuks in 1180. Here, turquoise tiles were positioned within hexagonal spaces at the centers of the bricks, aligning with the overarching hexagonal composition; however, brick remained the dominant structural and decorative element, with tiles employed sparingly. A further notable example is the Sivas İzzeddin Keykavus Tomb, constructed in 1217. This structure features a six-star composition integrating both tile and brick elements in the pediment, while hexagonal interlaced mosaic tiles are applied to the tomb facade, spandrels, and side iwan corner inlays of the associated healing center. The entrance (north) facade of the tomb was decorated with brick and tile mosaic as well as glazed brick and tile mosaics in the interior. The facade is decorated with a variety of geometric compositions, including stars, squares, and interlaced motifs (Yardımcı, 2013, 48). Another important feature of Seljuk-era tile decoration is the innovative use of color contrast, as exemplified by the İzzeddin Keykavus Tomb, where turquoise and purple tiles mark one of the earliest deliberate applications of chromatic differentiation in Anatolian tilework (Fig. 8). The Konya Sırçalı Madrasa, constructed in 1243, represents a significant advancement in tile techniques, showcasing extensive mosaic tile applications with hexagonal star compositions, particularly in the muqarnas and mihrab areas, dating from the second half of the 13th century. Similarly, the Malatya Ulu Mosque (1247) exhibits mosaic tiles on the courtyard portico and wall piers arranged according to a hexagonal scheme, incorporating glazed bricks alongside purple and turquoise tiles to enhance visual and structural effect (Yardımcı, 2013, 43).

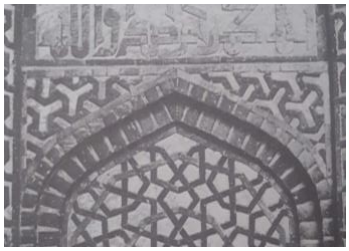

Figure 8: Sivas İzzeddin Keykavus Darüşşifa (1217), Hexagonal Interlaced Mosaic Tile Application, (Selçuk Mülayim, 1982, 140).

This example underscores the sophisticated use of geometric patterns in Seljuk-era Anatolia, reflecting both technical mastery and aesthetic considerations. The Konya Karatay Madrasa (1251) exemplifies the advanced craftsmanship of Seljuk tilework, particularly through its use of interior hexagonal patterns and the under-glaze rendering of the Seal of Süleyman (Solomon) motif (Fig. 9). In this context, each hexagonal tile was produced using meticulous under-glaze techniques, and gilded accents were added to articulate the intricate Solomon emblem. Within the motif, every hexagonal tile incorporates three drop-shaped decorative elements, while each equilateral triangle formed within the overall composition carries a single drop-shaped detail. This arrangement highlights both the technical precision and the rich symbolic layering characteristic of geometric ornamentation in Seljuk Anatolian architecture.

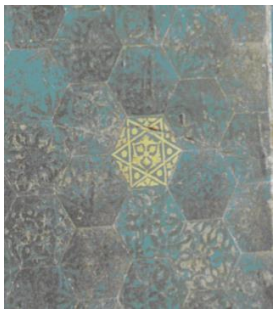

Figure 9: Konya Karatay Madrasa (1251), The Seal Of Solomon Symbolon A Hexagonal Tile, (İdil Türeli, 2011, 27).

In the Konya Sahip Ata Mosque (1258), the six-pointed star motif was executed using mosaic tilework. The design within the mihrab niche, rendered in turquoise and black tiles, was constructed through the intersection of evenly spaced vertical axes with lateral axes set at 30°–150° angles. This resulted in a precise linear composition, incorporating small equilateral triangles both within the hexagonal units and in the triangular spaces formed between them(Türeli, 2011, 28) (Fig. 10& 11).

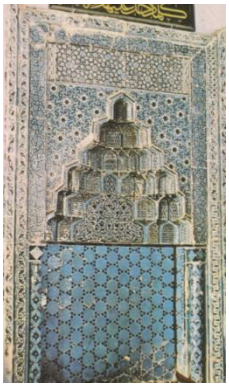

Figure 10: Konya Sahip Ata Mosque (1258), Hexagonal Tiles On Mihrab, (Türeli, 2011, 29).

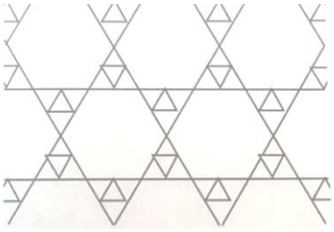

Figure 11: Konya Sahip Ata Mosque (1258), The Hexagonal Tile Designs In The Mihrab, (Demiriz, 2000, 33).

In the Konya İnce Minareli Madrasa, completed in 1279, hexagonal forms were employed in the spandrels using mosaic tile techniques, demonstrating the Seljuk mastery of geometric ornamentation. When considering secular architecture, the 12th-century Konya Kılıç Arslan (Alaeddin) Kiosk is particularly notable for its hexagonal composition adorned with minai tiles. The minai technique, developed during the Great Seljuk Empire in Iran, produced highly detailed polychrome ceramics, though its application on tiles in Iran during the 12th century remains undocumented(Öney, 2000, 30). In addition to minai, overglaze gilding was also employed, combining geometric foundations with figurative, vegetal, and rumi motifs to create complex ornamental schemes.

Within these compositions, small tiles are arranged to form complementary patterns that coalesce into larger geometric structures. For instance, in star-shaped arrangements, adjacent small hexagonal tiles construct intricate mosaic-like compositions: a central six-pointed star is encircled by diamond-shaped tiles, whose lower portions are angled to fit into the central star space, producing a secondary star form. This interplay of small units generates an overarching hexagonal pattern, exemplifying the Seljuks' ability to integrate modular geometry into architectural decoration. While geometric ornamentation appears in both religious and secular buildings, it is particularly dominant in mosques and madrasas, whereas in civilian structures, geometric and figurative motifs coexist, reflecting a balanced integration of abstract and representational design principles.

The Anatolian Principalities and the Early Ottoman period, it becomes evident that regional variations in political authority across Anatolia—spanning the east, west, north, and south—led to distinct stylistic and technical developments in tile production. In the east, under the influence of the Seljuk legacy; in the southeast, within the broader Islamic cultural sphere; and in the west, under the emerging Ottoman beylik, tilemaking evolved through the adoption of new materials and techniques. Although the glazed brick technique dominates

the decorative scheme of the Birgi Ulu Mosque (1312), its mihrab and muqarnas elements also feature mosaic tilework arranged in a six-pointed star composition. The Green Mosque of İznik (1391), commissioned by Grand Vizier of Sultan Murad I and renowned for its flat tile technique, incorporates hexagonal forms within the interlocking geometric band that adorns its minaret. Similarly, another notable example of the flat tile technique employing a hexagonal composition appears on the gallery landing entrance of the Green Mosque of Bursa (1421) (Fig. 12). Hexagonal motifs were also extensively used in the Green Tomb (Yeşil Türbe) of Bursa. In this monument, many of the tomb and wall coverings were executed using flat tile techniques, complemented by colored underglaze (cuerda seca) applications, reflecting the technical diversity and aesthetic experimentation characteristic of the early fifteenth century.

Figure 12: Green Mosque Of Bursa (1421), Hexagonal Tiles Around The Entrance To The Landing

In the Cem Sultan Tomb (1479) in Bursa, hexagonal wall tiles were executed using the flat tile technique (cuerda seca), rendered in deep cobalt blue and turquoise hues. A similar approach can be observed in the Şehzade Mahmut Tomb (1506) in Bursa, where comparable color palettes and compositional arrangements were employed. Another prominent example is the Muradiye Mosque (1435) in Edirne, commissioned by Sultan Murad II. The lower sections of its interior walls feature six-pointed star motifs composed of central hexagonal tiles surrounded by six adjoining triangular forms. The tilework was produced using the blue-and-white underglaze technique, characteristic of early Ottoman ceramic art. Notably, within one of the hexagonal tiles, a Seal of Solomon (Mühr-ü Süleyman) motif was executed underglaze, marking one of the earliest symbolic applications of this emblem in Ottoman architectural ceramics. In addition to geometric compositions, vegetal motifs are also discernible within several of the hexagonal forms. With the stylistic transition from the Late Seljuk to the Early Ottoman period, underglaze techniques gradually gained prominence. Tiles characterized by a hard, white fritware body, fine slip coating, and a transparent, glossy glaze became widespread, typically executed in a blue-and-white color scheme. By the fifteenth century, various stylistic schools emerged in İznik tile production—including the Baba Nakkaş, Haliç (Golden Horn), and Saz Yolu styles—each developing distinctive ornamental vocabularies while maintaining geometric foundations. These new aesthetic currents integrated floral and arabesque motifs into geometric frameworks through the use of refined underglaze painting techniques. Consequently, geometric ornamentation, once the dominant visual principle, began to assume a secondary decorative role within architectural contexts.

An exemplary manifestation of this stylistic evolution can be found in the Sünnet Room façade of Topkapı Palace, completed in the first half of the sixteenth century. The lower panels of the façade feature compositions in the Saz Yolu style, while the upper register displays a complex arrangement centered on hexagonal tiles surrounded by interlocking six-pointed stars (Fig. 13). Within the central hexagons, hatayi and penç motifs were rendered in blue-and-white underglaze decoration, illustrating both the technical mastery and aesthetic refinement achieved by Ottoman tile artisans of the classical period.

Figure 13: Topkapı Palace (1640), The Hexagonal Tile Patterns On The Façade Of The Circumcision Room

An examination of tile art during the Classical Ottoman period reveals the predominance of Damascus-style applications and later on with the emergence of semi-stylized ceramics, characterized by the introduction of the distinctive coral-red pigment. From the second half of the sixteenth century onward, significant advancements in decorative vocabulary, stylistic diversity, and technical sophistication became evident. Within this evolving aesthetic context, geometric compositions—once a dominant structural and symbolic element in earlier periods—gradually assumed a secondary, supporting role. Instead, floral, vegetal, and calligraphic motifs came to define the visual language of Ottoman ceramic ornamentation, reflecting the broader artistic synthesis achieved during the reigns of Sultan Süleyman the Magnificent and his successors.

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5 FINDINGS

This study demonstrates that the hexagonal form in Islamic art operates not merely as a decorative motif but as a generative structural principle through which mathematical order and symbolic meaning are simultaneously articulated. Owing to its regular geometry, capacity for seamless tessellation, and potential for infinite repetition, the hexagon provides one of the most efficient frameworks for establishing rhythm, continuity, and compositional unity across architectural surfaces. Rather than functioning as an isolated geometric preference, it serves as an organizing logic that structures ornamental systems through modular repetition, symmetry, and proportional coherence.The findings further indicate that the mathematical precision of the hexagon is consistently associated with metaphysical interpretations of order within Islamic aesthetic thought. In particular, the constructive relationship between the circle and the hexagon produces both measurable proportion and symbolic resonance. While the circle signifies infinity, unity, and the celestial realm, the hexagon introduces balance, structure, and harmonic division. Together, they create a visual language in which geometry becomes a medium for expressing cosmological and theological concepts. In this context, number and form are not merely technical devices but carriers of layered meaning.

Natural hexagonal formations, including honeycombs, crystalline structures, and floral symmetry, bolster this interpretive framework. But these examples don't work as literal copies in Islamic art; instead, they show abstract principles of stability, efficiency, and structural economy. The hexagon's ability to cover the most area with the least amount of material fits perfectly with the technical and material logic of tile decoration, where

modular assembly and surface continuity are very important. In this way, the form has both logical construction and symbolic density.

When looked at in a historical context, the hexagon's role shows how it changed over time over the Seljuk and Ottoman periods. In Seljuk architecture, the hexagon often serves as a primary structural grid, arranging mihrabs, tomb façades, and madrasa interiors into cohesive geometric networks. The use of mosaic tiles and color contrasts makes these systems clearer and more organized, emphasizing the hexagon's important role in the structure. In the early Ottoman period, hexagon-based star compositions continued this geometric tradition while also including more emblematic and apotropaic patterns, such as the Seal of Solomon. This made the form even more meaningful. During the Classical Ottoman period, as plant and calligraphic decorations become more important, geometric shapes slowly take a back seat. Still, the hexagon remains an underlying compositional framework, organizing decorative programming even when it is no longer the main visual focus.

In general, the study shows that the hexagon in Islamic art is more than just a decoration. This serves as both a mathematical tool for creating continuous surfaces and a symbolic framework representing ideas of unity, balance, holiness, and cosmic order. Its persistent existence across eras and locales substantiates its pivotal function within the comprehensive geometric lexicon of Islamic art.

6 CONCLUSION

The hexagonal form, deeply rooted in both the natural and mathematical order of the universe, emerges in Islamic art not merely as a decorative element but as a profound manifestation of the spiritual and intellectual worldview of Islam. Throughout history, the hexagon has served as a bridge between geometry and metaphysics, linking the measurable harmony of mathematical structure with the immeasurable depth of divine symbolism. Its presence across Islamic architecture and decorative arts—from the earliest Seljuk mosaics to the refined Ottoman tilework—demonstrates the enduring pursuit of unity, balance, and infinity, which are fundamental principles of Islamic aesthetics. At its core, the hexagon embodies the duality of simplicity and complexity. Its sixfold symmetry reflects a perfect equilibrium between the multiplicity of creation and the oneness of the divine. When repeated infinitely, the hexagonal grid becomes a visual metaphor for the infinite nature of God (Al-Bāqī), where the boundary between the material and the transcendent dissolves into rhythmic continuity. This mathematical repetition, often framed within circular compositions, gives form to the Qur'anic notion of divine order in creation—"He created all things in due measure" (Al-Qamar 54:49). Hence, the geometry of the hexagon is not arbitrary; it functions as a sacred signifier that transforms surfaces into metaphysical expressions of divine perfection.

Historically, the development of hexagonal compositions in Islamic art reflects both technological evolution and philosophical maturity. In the Seljuk period, the integration of hexagonal patterns in tilework—such as those seen in the Sivas İzzeddin Keykavus Tomb and the Konya Karatay Madrasa—illustrates a highly advanced understanding of modular geometry and spatial harmony. The Ottoman period inherited and further refined this legacy, applying the hexagon within increasingly sophisticated underglaze and cuerda seca techniques, as evident in the Bursa Green Mosque and Tomb. Through these architectural examples, the hexagonal form transcended its function as surface ornamentation to become an organizing principle of sacred space—where mathematical order and spiritual contemplation converge.

The symbolic resonance of the hexagon extends beyond its visual geometry. Its sixfold division echoes the six days of creation described in the Qur'an, linking artistic practice to cosmological meaning. The completion of the hexagon by an encompassing circle, representing infinity, visually expresses the unity of existence (tawḥīd)—a concept central to Islamic theology and Sufi metaphysics. Within this framework, geometric design operates as a form of silent theology: an abstract language through which artists articulate the ineffable nature

of divine reality without resorting to figural representation. Thus, the hexagon, as both a natural and symbolic form, becomes a visual articulation of the harmony between divine order and human creativity.

In conclusion, the study of the hexagonal form in Islamic art reveals the depth of intellectual, spiritual, and aesthetic synthesis achieved within the Islamic cultural tradition. The hexagon's mathematical precision, its occurrence in nature, and its layered symbolism collectively demonstrate the capacity of Islamic art to transform scientific rationality into spiritual vision. As a recurring and unifying motif, the hexagon serves not only as a testament to the technical mastery of Islamic artisans but also as a reflection of a worldview in which geometry, faith, and beauty are inseparably intertwined. Through the enduring language of geometric ornamentation, Islamic art communicates the profound truth that all multiplicity originates from unity—a principle as eternal and harmonious as the hexagon itself.

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