

Analysis of the Design Structure System of a Safavid Qabi Carpet in the Metropolitan Museum of Art, New York

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Abstract: Safavid carpets are Persian historical masterpieces. They represent original structures with wonderful motifs. Some of these were designed according to specific patterns that indicate a connection between principles and structures according to geometry, and are also based on the Persian authentic traditional design. This study attempts to explain and analyze its pattern and structure. This carpet, named “Qabi,” is in the Metropolitan Museum in New York City. The research method is qualitative, and it involves library and internet resources, which are presented in a descriptive-analytical manner. The limitations of structural research on historical Persian carpets and the lack of knowledge of their structure are so important and necessary. The result of this research shows that the structure of this Safavid carpet was based on a kind of geometric aesthetic ideology. On the other hand, the most important result of this research on this carpet is the design that was based on geometric trelliswork. This trelliswork (Girih) is Roundel (Shamsa), Octagon, and Star (Arusak).

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1. Introduction

Persian carpet weaving is among the most distinctive expressions of Iranian art and culture, long valued not only for its practical function but also as a symbol of Iranian aesthetic identity (Pope, 1978: 245). Among historical periods, the Safavid era marks the peak of this artistic tradition; with courtly patronage and the establishment of royal workshops, carpet production reached a level that Western sources have described as a “renaissance of the Persian carpet” (Erdmann, 1960: 87). One of the most important design achievements of this era was the formation of a coherent and highly functional geometric system. Based on geometric subdivision of the surface and the orderly repetition of motifs, this system produced a spatial discipline and visual unity that clearly distinguished Safavid carpets from pre-Safavid examples (Ayatollahi, 2005: 112). Safavid carpets, therefore, are significant not only aesthetically but also historically, reflecting the continuity of Timurid and Turkmen design traditions alongside Safavid innovations (Dimand, 1929: 54).

Among the key approaches to studying carpet art is the analysis of structure, pattern, and design elements that, together with color, symbolism, and meaning, determine a carpet’s artistic value. In historical carpets, little direct evidence survives regarding design methods; however, close examination of surviving examples reveals identifiable aesthetic preferences and systematic design procedures, suggesting the presence of an underlying, pre-planned structural order. This raises the essential question of the principles governing such compositions. While some researchers claim that Iranian designs follow no strict rules and rely mainly on freehand composition, recent studies point to a hidden structural system that organizes design layouts and guides the artist.

The structure and design methods of historical Iranian carpets are thus of great importance. In traditional design, especially carpet design, the notion of “structure” is closely tied to geometry, which functions as the visual grammar of Iranian art and the foundation of compositional organization (Yaghoubzadeh, 2022: 62). By examining the stages followed by carpet designers, one can identify geometric features that reveal the underlying structure and method of design, including the overall layout, motif composition, field-and-border divisions, and the distribution of secondary elements. Understanding these governing principles enables accurate analysis of the historical development of Iranian carpet designs. Existing scholarship shows that researchers have repeatedly struggled with identifying structural design systems, and no comprehensive source on the structural analysis of classical Persian carpets exists. Thus, studying practical methods to enhance structural understanding is essential, as misinterpretations have led to incorrect naming or classification of some carpets.

One notable example is the Safavid compartment-design (“qābi”) carpet held in [the Metropolitan Museum of Art](#) in New York. Its complex geometric organization and highly integrated composition offer rich material for analyzing the genealogy of design systems. Studying this carpet can illuminate both the continuity of earlier design traditions and the innovations of the Safavid period. Accordingly, the central research question is: How was the geometric and structural design system of the Safavid compartment carpet formed, and how does it relate to the historical lineage of Persian carpet design? The aim is to analyze the structural system of this carpet, identifying its geometric and repeat-unit principles and tracing their historical roots within the broader tradition of Persian carpet design.

2. Research Methodology

Despite the wealth of visual documentation and scholarly attention given to Persian carpets, the internal compositional systems of many Safavid works remain insufficiently explored. Much of the existing literature has focused on stylistic classification, historical attribution, or iconographic interpretation. However, fewer studies have attempted to decode the geometric scaffolding and the embedded design logics underlying these visual forms. This gap is especially evident when examining the complex patterns and layered compositions seen in Safavid urban carpets. In particular, Qabi carpets, so named for their compartmentalized, paneled structure, offer unique insights into the application of traditional Islamic geometric principles within textile art. The study of these systems is critical not only for understanding Persian carpet design but also for appreciating the broader philosophical and mathematical ideas that shaped Islamic art. Moreover, the lack of systematic analytical tools and structural diagrams in previous research has created a challenge in fully apprehending the logic of such works. This study seeks to bridge that gap by applying a methodologically grounded approach that integrates traditional design theory with visual analysis. The research is qualitative in nature, classified as both fundamental and exploratory. It employs a descriptive-analytical approach, relying on a combination of library-based archival research, digital resources, and visual analysis techniques. Historical manuscripts, design treatises, and previous studies on Islamic geometry and Safavid art were examined to provide theoretical grounding.

3. Results

3.1. Analytical Framework of Structural System

Geometric motifs have a long and continuous history in Iranian art. In prehistoric ceramics, such as those from Susa and Sialk sites, examples of radial and circular divisions as well as repetitive patterns can be observed, representing some of the earliest attempts to establish visual order. During the Achaemenid period, although greater emphasis was placed on animal and vegetal motifs, the application of geometric proportions and mathematical order is clearly evident in the architecture of Persepolis and its reliefs. In the Sasanian era, the use of polygons, stars, and symmetrical lozenges in stucco decorations and textiles became widespread, providing the

foundation for the emergence of more complex trelliswork (Girih: traditional Islamic geometric Patterns) in the Islamic period. Evidence of this development can be seen in the design of the oldest known carpet in the world, the Pazyryk carpet, which is characterized by geometric proportions, balance and harmony, rhythm and movement, repetition, the integration of positive and negative spaces across the entire surface, and ultimately a unified composition (Akbari, 2015: 21).

With the advent of Islam, two fundamental factors led to a conceptual transformation in Iranian decorative geometry: first, the avoidance of figural representation and the increasing emphasis on abstract motifs; and second, a philosophical and mystical inclination toward cosmic order and the concept of unity in multiplicity. A historical investigation of the conceptual development of the “geometric trelliswork” in Iranian art demonstrates that these patterns emerged from the synthesis of mathematical knowledge, a cosmological worldview, and Iranian–Islamic aesthetic traditions. Following the rise of Islam and the flourishing of geometry, this trelliswork developed into increasingly complex and seemingly infinite systems during the Seljuk, Ilkhanid, and Timurid periods.

The attention paid by skilled painters to carpets during the eighth and ninth centuries AH had, by the late ninth century, become a fully professional practice. This attention reached such a level of precision and meticulousness that narrow subsidiary borders were delicately adorned with slender, intricately winding vine branches, interlaced motifs, and small, pointed scalloped forms. In illustrated manuscripts produced over fifty years between 890 and 940 AH, several carpets are depicted, revealing a high level of technical mastery and a thorough understanding of carpet design principles; this may, where necessary, be regarded as evidence of a close relationship between these two arts (Pope & Ackerman, 2008: 2).

During the Safavid period, the concept of the geometric trelliswork reached its peak of development and was employed as a basis for order, proportion, unity, and the reflection of divine order in tilework, stucco decoration, book arts, and especially carpet design. In this transformation, the trelliswork evolved from a mere decorative motif into a fundamental structural system organizing form and space, thereby consolidating its central role in creating visual coherence and expressing the worldview of unity in multiplicity.

From this point onward, geometric trellisworks functioned not only as decorative elements but also as manifestations of divine order and a monotheistic worldview. Geometry in Iranian Islamic art came to serve as a universal language for expressing infinity, repetition, and the manifestation of the sacred. A review of the history of design indicates that, under specific cultural, religious, and social conditions, significant transformations occurred in the patterns and designs of Iran’s traditional arts. At the same time, it is essential to emphasize that an understanding of wisdom and its position within the design process, manifested through the application of particular principles and rules, has always been of fundamental importance in traditional works. Iranian art and architecture have consistently drawn inspiration from geometric principles, methods of geometric construction, and the deliberate application of specific geometric systems within broader intellectual and philosophical frameworks (Lawlor, 1989: 41).

During the Seljuk and Ilkhanid periods, geometric trelliswork construction became one of the most distinctive features of architecture. Six-, eight-, ten-, and twelve-pointed star patterns, along with complex polygons, were widely employed in tilework and brickwork. Iranian artists, using principles derived from the division of circles, squares, and triangles, generated a variety of geometric grids that were later documented in architectural treatises under the term trelliswork. In the Timurid era, particularly within the Herat school, this tendency reached its apex. Timurid tilework in Samarkand and Herat represents outstanding examples of geometric complexity that continued into Safavid architecture.

The Safavid period constitutes a turning point in the evolution of geometric trellisworks. In this era, geometric systems became prominent not only in architecture—such as the Sheikh Lutfollah Mosque, the Shah Mosque, and the Chahar Bagh Madrasa—but also in carpets, textiles, book arts, and even metalwork. A major Safavid innovation was the integration of geometric grids with

arabesque (eslimi), khata'i, and naturalistic floral motifs. This synthesis produced a dialogue between abstraction and naturalism that defined the distinctive identity of Safavid art. Safavid panel carpets represent the finest examples of this approach: the orderly framing of the carpet surface based on geometric trellisworks—square, polygonal, and star-shaped—provided a framework for the repetition of design units and the integration of vegetal and animal motifs. This process elevated the Iranian carpet beyond a purely functional object, transforming it into a medium for expressing philosophical and aesthetic concepts.

Geometric trellisworks in Iranian art fulfilled several fundamental functions:

1. Aesthetic: the creation of harmony, balance, and visual diversity.
2. Conceptual: the representation of divine order, unity in multiplicity, and the evocation of infinity.
3. Functional: the organization of space, division of surfaces, and the establishment of compositional coherence.
4. Identity-related: the reflection of Iranian Islamic cultural identity as a synthesis of ancient traditions and Islamic teachings.

The development of geometric trellisworks exerted a profound influence not only in Iran but throughout the Islamic world; nevertheless, the distinctive Iranian character is evident in the integration of geometry with poetic sensibility and vegetal motifs. This tradition has continued into the modern era and remains strongly present in Iranian architecture, carpet design, and handicrafts.

3.2. Geometric Design System in Carpet Design

components of a composition. In carpet analysis, structure is understood at two levels: the overall (external) framework of the design, and the internal arrangement of motifs and elements (Yaghoubzadeh, 2022: 76). This study focuses primarily on the overall structure. A central issue in examining historical Persian carpets is understanding their design methodology. While it has long been assumed that weavers used fully gridded cartoons in which each colored square indicated a trelliswork, a method still used in many urban and some rural carpets, historical evidence suggests the presence of two distinct approaches. Small, asymmetrical designs were drawn as paintings, whereas large and symmetrical carpets required gridded and calculated patterns, since memorizing the placement of every trelliswork was impossible (Piri, 2021: 153). Although direct written evidence on early carpet cartoons is limited, scholars such as Gülrü Necipoğlu argue that the use of underdrawings based on geometric grids likely began during the Timurid period, as evidenced by examples in architectural scrolls. Maies Nazarlı (2011) notes that Persian miniature painters combined pictorial representation with traditional Islamic drafting techniques, widely used in the medieval period for geometric ornament and architectural plans. Though such structures may not be immediately visible to the observer, their visual logic becomes apparent through repetition and practice. These methods were also employed in traditional carpet design, where the combination of soft, organic compositions with the discipline of geometric rules produced balanced and coherent patterns comparable to those in woodwork, tilework, and manuscript illumination. Geometry has always held aesthetic and structural importance in Iranian art, serving as a means of expressing balance, harmony, and order.

As a mathematical discipline concerned with spatial relations, geometry has long been used to shape and organize artistic forms. Geometric ornament is among the oldest decorative methods across Iranian arts. Principles of “fundamental geometry”, including proportional divisions, basic geometric shapes such as squares, triangles, semicircles, logarithmic spirals, and transformations such as rotation and reflection, enabled artists to create harmonious compositions. Understanding geometric systems is essential for traditional Iranian design, as these systems underpin the idealization of classical carpet patterns and can be traced back to ancient times. In classical Persian carpets, geometric systems of dimension, layout, motifs, and visual and chromatic aesthetics merge into an integrated whole known as the “structure” of the carpet. While geometric templates dominated carpet design in the 8th century AH – the early 9th century AH, they were

gradually replaced by curvilinear and more intricate compositions, marking a significant transition from rigid geometric schemes to fluid and dynamic designs.

3.3. Evolution of Structural Design in Safavid Carpets

The Safavid era marks a turning point in the emergence of a new style of Iranian carpet, known as the urban style, which introduced innovative and original patterns while strengthening the foundations of traditional design. Safavid carpets, supported by the royal court and produced with the finest materials and the most skilled artisans, represent the masterpieces of classical Persian weaving. Numerous examples from this period, considered the golden age of Persian carpet production, survive today in major museums worldwide. One of the notable strengths of Safavid carpets lies in their inventive motifs and compositions, which give them their distinctive character. Many of these carpets were designed by eminent court artists such as Kamāl al-Dīn Bihzād of Herat, a leading painter of the Herat, Bukhara, and second Tabriz schools, as well as Ghiyāth al-Dīn Jāmī, Soltan Mohammad, Ostād Seyyed Ali, and others (Yavari, 2014: 241).

During this period, close interaction among artists from various fields, illumination, manuscript illustration, and book arts, led to artistic innovations and the introduction of new carpet designs (Shadlou, 2020: 100). Although written sources on design processes are limited, the rich structural coherence and traditional design principles of the Safavid era are clearly evident.

The artistic developments of the 9th century AH can be traced through changes in weaving techniques and motif structures: geometric and angular designs gradually gave way to curvilinear compositions. Whereas pre-Safavid carpets predominantly featured geometric and square compartment layouts, Safavid carpets embraced flowing arabesques and rounded forms. This shift reflects a movement from geometric discourse to softer, more ornamental curvilinear design, shaped by the diverse artistic experiences of Safavid designers (Mirzaiee, 2019: 234). Hillenbrand also emphasizes the importance of geometric structure and systematic patterns in the Safavid period.

4. Findings and Discussion

The carpet examined in this study is a fine Safavid example preserved at the Metropolitan Museum of Art in New York, measuring 497 × 340 cm and registered under accession number 10.613. It dates to the early 16th century CE / 9th century AH and represents one of the masterpieces of the urban Safavid weaving tradition. The carpet is woven with silk warp and weft, wool pile, and asymmetric trellisworks (URL1). It features dragon–simurgh combat motifs, along with *eslimi* and *khatai* patterns, and its place of manufacture is unknown, though it was likely produced in Tabriz or Kashan.

The carpet stands out for its unusual design, distinctive compositional principles, and highly developed geometric substructure. Persian sources commonly refer to its layout as a *qābu-qābi* (compartment) design, while a few describe it as *bāzubandi*. At the Metropolitan Museum, it is catalogued as a “Compartment Carpet with Repeating Units” (Ibid). Notably, only a small number of Safavid carpets employ compartment designs, making this example particularly significant (Jouleh, 2014: 21).

The *qābi* design in Persian carpets (Fig. 1) can be identified through variations in the size, form, and structure of the compartments, their exterior and interior ornamentation, the subjects depicted within them, the configuration of connecting motifs, and the arrangement of colors. Although compartment designs have a long history in Iranian visual culture, they gradually evolved through innovations such as checkerboard-like division of the field, differentiated coloring of compartments, diverse internal motifs, and modified connective structures. Scholars consider the *qābu-qābi* pattern to have developed from the *kheshti* layout, itself derived from *bāghi* (garden) plans (Hasouri, 2002: 30). Evidence from other arts indicates that such designs existed before the Safavid period, and in Safavid times, numerous regional variants, such as those of Jowshaqān, were produced (Tofighi & Espanāni, 2012: 18).

Early Safavid carpets reflect a shift away from rigid geometric motifs toward curvilinear and ornamental forms, with the *band-e rumi* (Roman trelliswork motif) playing a central role in this transformation; complex radial compositions gradually replaced simpler orthogonal networks (Necipoğlu, 2000: 154). Hillenbrand argues that many designs likely originated in royal workshops before spreading to other arts (Hillenbrand, 1999: 21). In Safavid design practice, the main structural framework was often overlaid with refined, delicate motifs, resulting in highly integrated compositions.

In the examined carpet, the field is divided into square compartments, each decorated with its own set of motifs. The *Repeated unit* (Vagireh) inside each compartment conforms to the geometric rules of traditional trelliswork design. The aesthetic appeal lies not only in the visible motifs but also in the invisible geometric structure that organizes the composition through symmetry, proportion, and systematic repetition. The Repeated unit serves as the smallest repeatable unit, which, through directional repetition, forms the *trelliswork*. The underlying grid—square, triangular, or lozenge-based—establishes the design’s structural logic. Four major methods of constructing trellisworks include the stellar, node-connection (Moroccan), grid, and polygonal systems (Nejad-Ebrahimi & Azizipour, 2023: 104). The study assumes that analyzing the carpet’s structure can reveal the visual relationships and geometric drawing rules that inform its design.



Figure 1. The so-called “Qabi” Carpet, Metropolitan Museum of Art, New York ([URL1](#)).

Analyses indicate that the primary origin of the carpet’s Repeated unit lies in one of the “group-eight” trelliswork patterns, specifically the Octagon, Roundel with Star, constructed upon a square sub-grid and generated through node-connection, reflective symmetry, and translational repetition. The extensive overlap of the pattern’s elements confirms the hypothesis of a highly ordered geometric substructure derived from traditional trelliswork design. Group-eight trelliswork patterns are among the most complex and widely used motifs in Islamic-period Iranian architecture and the decorative arts, valued for their capacity for continuous repetition and dynamic expansion, enabling artisans to produce numerous artistic masterpieces.

A trelliswork is composed of specific elements (*ālt*), which recur consistently throughout the pattern; the presence of these identifiable components is the key distinguishing feature separating trelliswork from other geometric constructions (Helli, 1986: 64). Each element bears a particular

name, often derived from natural forms—animals, plants, or objects—based on visual resemblance. To verify proportional accuracy, the researchers reconstructed a sample *repeated unit* and superimposed it onto the original carpet design. Close examination of the overall geometry showed that the structural, regulating components align precisely with the layout of the *Repeated unit* (Fig. 2, Fig. 3, Fig. 4, & Fig. 5).



Figure 2. Repeated unit of the Carpet Design (Detail from the Main Pattern).

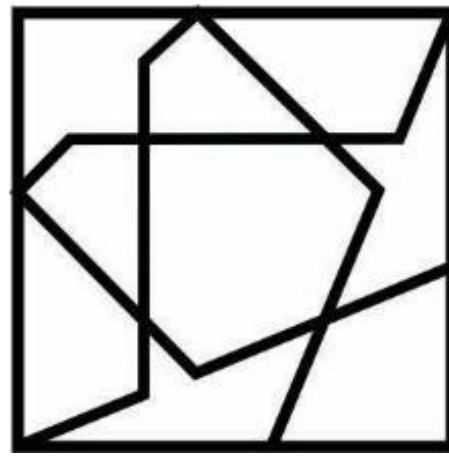


Figure 3. Eight-Pointed “Roundel and Star” Geometric Design.

Table 1. Elements of the trelliswork





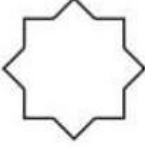
Trelliswork	Star (Arusak)	Octagon (Hasht)	Shesband	Torang	Roundel (Shamsa)
Octagon and Star					



Figure 4. Translational and Reflective Repetition of the Repeated unit to Form the Main Eight-Pointed “Roundel and Star” trelliswork Pattern.

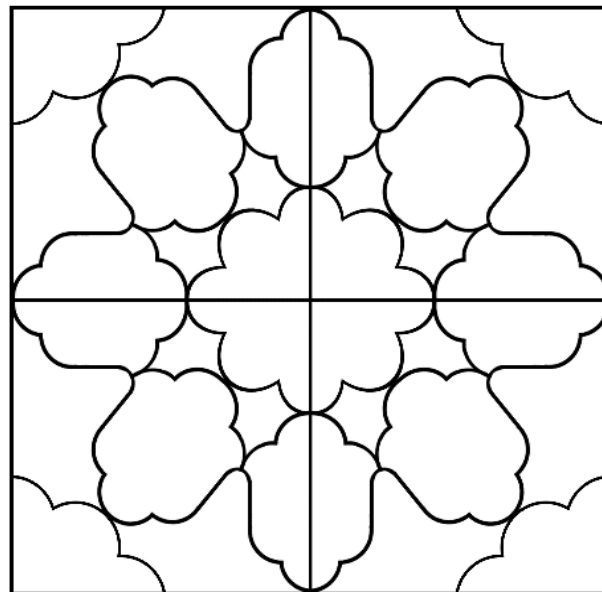


Figure 5. Boundary Lines of the Repeated unit Pattern and trelliswork Replication.

Procedure for Deriving the Construction Method of the Eight-Pointed “Roundel and Star” trelliswork:

1. Consider the square **ABCD**.
2. Draw the diagonals of the square.
3. Divide angle **A** into four equal parts.
4. Let the intersection of the first ray with the diagonal of the square be point **O**.

From this point, draw a line parallel to the horizontal sides of the square so that it intersects the second and third rays at points **N** and **M**.

Let the intersection of the third ray with the diagonal be point **Q**.

From point **Q**, draw a line parallel to the vertical sides of the square so that it intersects the second and third rays at points **L** and **M**.

5. Using **A** as the center and **AN** and **AM** as radii, draw two arcs.
6. Extend the line from point **1** to point **Q** until point **R** is obtained.
7. Extend the line from point **2** to point **O** until point **P** is obtained.
8. Connect point **B** to **P**, and point **D** to **R**.
9. Identify and mark the points of intersection.
10. Clarify the main trelliswork lines and remove the construction lines (Fig. 5, Fig. 6, and Fig. 7).

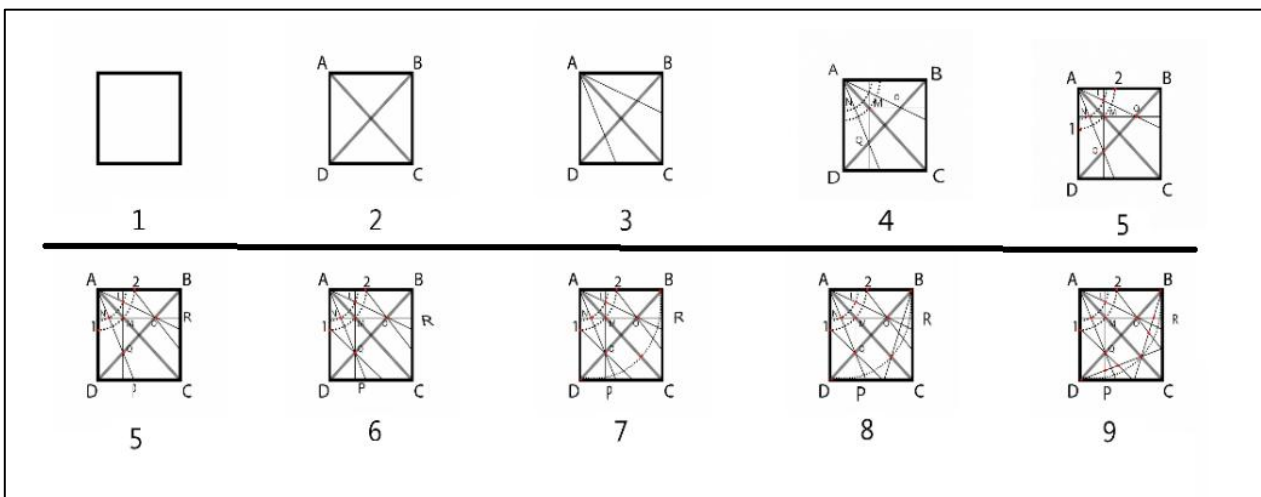


Figure 6. Explanation of the Repeated Unit Structure of the Carpet Design Using the Node-Connection Method.

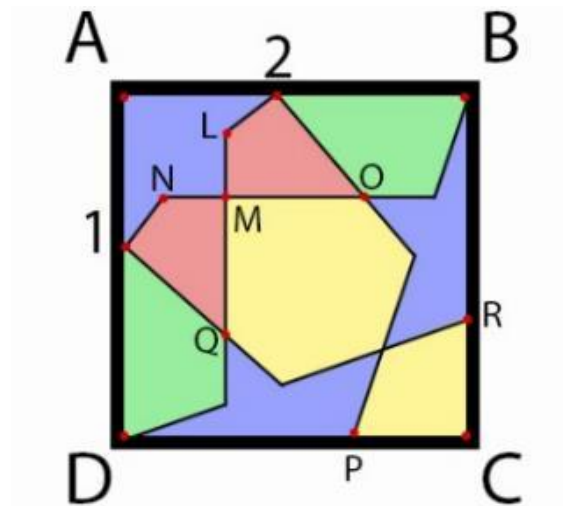


Figure 7. Final Design with Separation of Trelliswork Elements.

The designed pattern was overlaid onto the main carpet design. However, certain areas of the carpet exhibit elongation, resulting in a misalignment of the pattern units with the carpet design. In the upper and lower sections of the carpet (Fig. 8), the pattern units are not fully rendered, likely due to the specific proportions and dimensions of the carpet. The designer skillfully arranged the pattern units within the field of the carpet, and in these sections, the units are necessarily only partially executed.

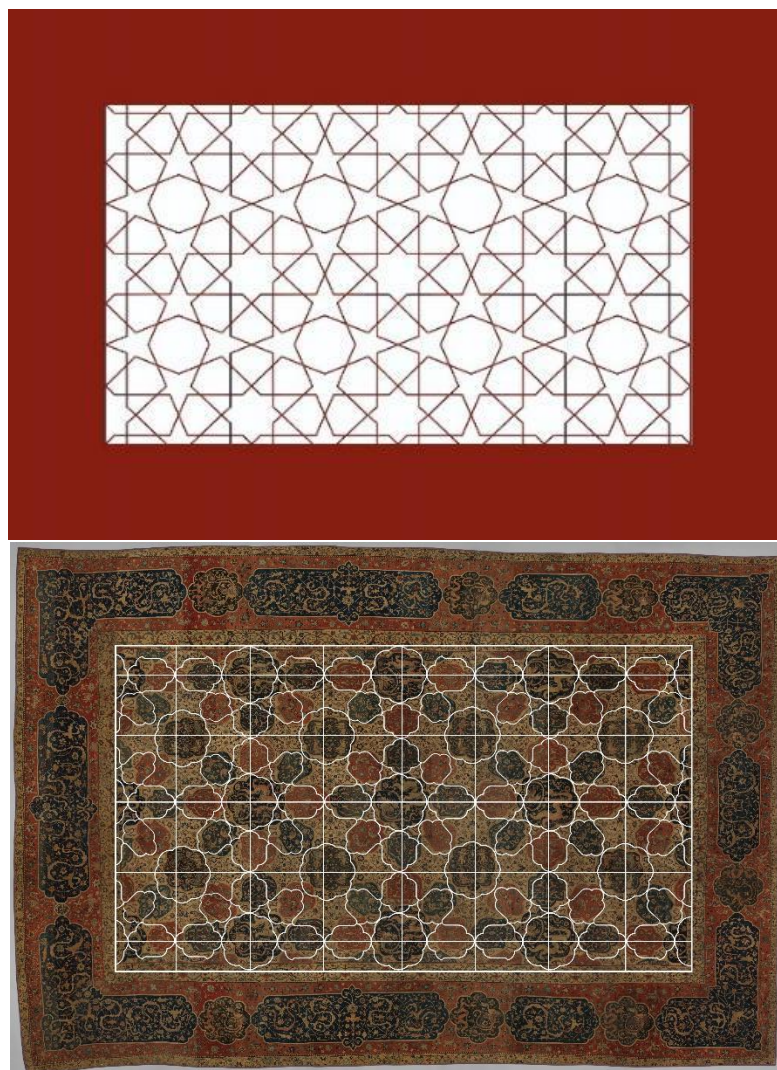


Figure 8. Geometric Trelliswork: Design and Arrangement of Repeated Units in the Carpet.

5. Conclusion

This study demonstrates that the Safavid Qabi carpet in the Metropolitan Museum of Art is more than a decorative artifact; it is a structured expression of geometric and philosophical thought embedded in Persian artistic tradition. By analyzing its composition through the lens of traditional *trelliswork* geometry and symbolic design, we uncover the intellectual framework that guided its creation. The findings suggest that the carpet's design logic is not incidental but rather a deliberate manifestation of a geometric aesthetic rooted in Islamic cosmology and Persian artistic heritage. This reinforces the idea that Safavid carpets were products of sophisticated artistic systems where form, function, and meaning intersected through design. Furthermore, the research highlights the importance of ongoing structural and comparative studies of Persian carpets, employing interdisciplinary methods. As historical artifacts, these carpets offer invaluable insight into the visual intelligence, philosophical depth, and technical mastery of one of the world's greatest artistic civilizations.

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Authors' Contributions

The first author conducted the literature review, developed the initial manuscript structure, and performed the scientific editing. The second author proposed the original research idea, performed the geometric structure analysis, and was responsible for the final revision of the manuscript.

Conflict of Interest

The authors report no conflict of interest.

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Access to Materials and Data

The data of this research will be accessible through correspondence with the authors.

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