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Geometry of Virtual Spirals in *Qalib Kari: Case study of tomb of Dai Anga*

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Abstract

Mughal architecture has been widely recognized for the use of geometry in planning and physical design, but it has not formed the subject of vigorous research in Pakistan. Mughals utilized geometry for the construction of domes, Muqarnas and production of stalactite decoration locally known as Qalib Kari. This Qalib Kari or interior decorations utilized in Mughal era domes represent elaborate geometrical designs with interlacing stars. These ornamented domes of Mughal architecture are unique and represent the level of knowledge and dexterity attained in Mughal era. Nevertheless, there is inadequate historical information available about the decoration of the domes' interiors, although this was a most sophisticated program. Studies on decorations on arches and domes show different arrangements of particular elements create diverse patterns. However, these researches overlooked one point that in some cases, this arrangement also creates the optical illusion of curvilinear pattern, like a flower, on the inner spherical surfaces of domes. The author intends to focus on this illusion of curvilinear pattern and the dome of Dai Anga's tomb (d. 1672) is the case study for this purpose. There has not been any such research in this regard and this is a relatively unknown area of research. For this study, different geometrical curves were superimposed on drawing of dome's decoration in Autodesk AutoCAD. This research will help in further investigations concerning geometrical knowledge of domical decoration by the maymars (architects) of that time.

Acknowledgments: *Kamil khan Mumtaz Architects for giving this opportunity to document the dome of Tomb of Dai Anga. Dr. Abdul Rehman for providing guidance on conducting good research.*

1. Introduction

Stalactite patterns or *Qalib Kari*, on a dome's interior surface, is one of the characteristic features of Mughal architecture, which draws its inspiration from Persian-Islamic architecture. The study of these stalactite dome patterns are archetypal decorations and are significant for spherical geometry on interior surfaces of the domes. This paper does not discuss the possible process involving complex geometric systems as a founding principle behind this accomplishment of early Mughal architects. Instead, it takes into account one of the aspects of the end-product which adds to the complexity of the design. The paper studies the arrangement of shapes in such a way that these shapes guide observers' eyes to move along a curve on spherical domes, however, there is no curve and centrifugal arrangement of shapes make the pattern. These virtual curves also form flower-like patterns on rhythmic repetition. This paper tries to understand the geometry of these virtual curves and formation of the flower-like pattern and is limited to the decoration aspects only.

There are four parts of the structure of the paper: The first part deals with the geometry in Islamic architecture and background of stalactite domes. The second part deals with the description of the tomb, its significance and presents a methodology for analysis of the dome's decoration. The third part deals with a literature review to understand the background of the geometrical curve used in research. The fourth part concludes the findings and compares other similar Islamic decorative domes with the findings.

2. Islamic Architecture and Geometry in Medieval Islamic Era

Mathematics, art, and architecture are three diverse disciplines that share a unique relationship in Islamic architecture. Middle Islamic era, mainly 10th to 13th century, saw the progress of Muslim architects who were also mathematicians and applied their knowledge for structural stability, for creating spatial harmony and building decorations. Architectural marvels from Islamic past portray this relationship in every aspect of the building, and many studies show Islamic architecture was dependent on geometric systems. Middle age Muslim architects, specializing in the area of mathematics, also generously contributed to the art of decoration involving abstract and geometric patterns. Furthermore, many books written by Muslim mathematicians, in middle age, on subjects of architecture and mathematics indicated the involvement of mathematics in perfecting the art of building. These books provided a groundwork for use of geometry for planning as well as decoration for buildings. For example, books such as "Geometric Constructions needed by a Craftsman" (فيما يحتاج اليه الصانع من الاعمال الهندسه) by Abul Wafa al Buzjani (CE 940-988), "A key to Arithmetic" (مفتاح الحساب) by Jamshaid al Kashi (CE 1380-1429) and "Unknown Arcs of a Sphere" by Al-Jayyani (CE 989-1079), are a few of the acknowledged examples.

These books also included texts for architectural use to aid architects of that time. Other than planning, these books provided the basis for the decorative patterns. Evolution in culture, technology, and variations in geographical and climatic conditions created diversity in these patterns and decorations. Researchers today are still searching for clues regarding the complex systems used by these architects who dwelt and practiced their profession in the medieval Islamic era. One such example is the recent discovery of patterns based on quasi-crystalline geometry in medieval Islamic architecture discussed by Peter J. Lu and Paul J. Steinhardt in 2007. Other important decoration that has held researcher in awe is stalactite decorations e.g., Qalib Kari. There is significant discussion available from primary sources that shed light on the components and their proportions. Today's scholars often refer to these books to understand the role of geometry in Islamic architecture. This practical knowledge also reached subcontinent through Persian influences who became master mason of that time. They developed and perfected their own system for design of such stalactite decorations and named them based on formation.

2.1. Mughal Islamic Architecture

The Mughal architecture of the subcontinent also owes much to these early scholars. Through their unique approach, geometric patterns used for decoration became a distinctive feature of Mughal architecture. There have been many studies regarding geometric systems used in planning, volume synchronization and creation of harmony and spatial balance in Mughal architecture. In addition, researchers also dealt with the harmony and composition of elements on façade. Therefore, planning and decorations are two broader aspects of these researches. For the earlier aspect, one example is an analysis of Taj Mahal based on a modular system (Koch, 2006). Similarly, the modular architectural design of Tomb of Humayun's complex and the Taj Mahal complex seems to follow basic measuring units (Balasubramaniam, 2010). In contrast, the façade of the tomb of Sheikh Zahed-e-Gilani of Timurid/Turkmen architectural style follows a different geometric scheme. In this case, Intentional geometric order based on Isosceles triangles, and the octagons inscribed within squares formed the master diagram for giving form to the mausoleum. These basic geometric shapes determined the relationship of the dome with the rest of the facade (Ahmadi, 2012). In addition, some studies on domes, vaults, and arches of traditional Islamic architecture have focused on different aspects like structure, the arrangement of elements, geometry. For example, research by Castiglia and Bevilacqua in 2008 emphasizes the geometry of arches of Albanian baths with Ottoman roots. The researcher analyzed the curvature in the arches of the hammam of Kala, Elbasan, Albania. Although this research established the structural constitution and the curvatures of these arches, they missed, however, to elaborate upon the stalactite decoration found on the interior of the curved roof surfaces.

Similarly, decorative patterns in Mughal architecture also attracted many researchers. These patterns can be divided into two and three-dimensional spherical decorations. Two-dimensional decorative geometrical patterns were abundantly used on walls and jalis of Mughal monuments. On the other hand, geometric patterns on domes and arches in Mughal architecture make the three-dimensional patterns based on spherical geometry. These decorations have different distinctive elements such as interlacing stars, stalactite components, and radial symmetry. Furthermore, these decorations on ceilings of domes and arches had a close relationship with geometry and constituted a major feature of Islamic decoration.

2.2. Background of Stalactite type decorations

Traditional Islamic domes and arches always had distinguished stalactite ornamentation, and these decorations had different names based on their placement in the building and geographical location of the building. Muqarnas, Yazdibandi, and Qalib Kari are examples of different names given to these decorations. Muqarnas was evolved to visually relate two different geometric volumes like the square room and the dome or cylindrical drum. The word Muqarnas, or a stalactite vault, had its origin in the

Arabic language. As an architectural feature, it developed in Iran and almost at the same time, but probably independently, in central North Africa. It is a three-dimensional architectural decoration forming elements like niches and arranged in tiers. Projection of a Muqarnas vault on paper consists of only a few types of elements (Samplonius & Harmsen, 2004). This connection of two different volumes of square room and round drum of the dome was strikingly negative in both the interiors as well as the exteriors. The problem of connecting two different volumes was also a distinctive feature of some Ottoman minarets. The two shapes, of the prism and the cylinder, were connected as harmoniously as possible, geometrically (Parzysz, 2011).

In the same way, the decorative works on Persian's domes were categorized based on the composition of elements and placement on domes. There were mainly three categories, i.e. Karbandy, Rsmybundy and Yazdibundi. Karbandy (کاربندی) is a coverage for dome ceiling. It is based on certain geometric rules that define parameters for arcs to intersect and shape dome's interior. (Mansoor & seena, 1990, pp. 98,99). In this case, an arch is the basic unit and its repetition around the center of a dome creates interesting patterns.

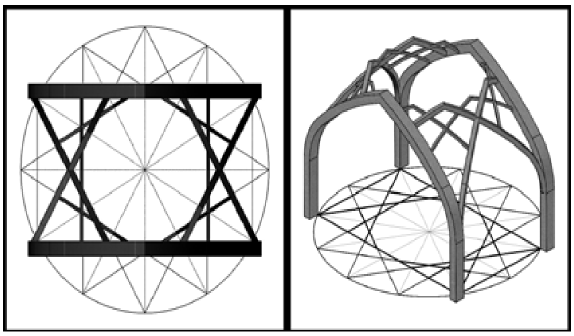


Fig. 1: Plan, three-dimensional model and components of Karbandy. Source: (Mansoor & seena, 1990, p. 99)

General Principles of Karbandy and Rsmybandy (رسمی بندی) are similar but in Karbandy arcs intersect to decorate the lower part of the dome and shapes are not very different from each other. Rsmybandy is further divided into two types called Rsmy Qalib Srsft (رسمی قالب سرسفت) and Rsmy Qalib Shaghuly (رسمی قالب شاغولی). The first category, Rsmy Qalib Srsft, is shown in Fig. **2**. It has almond- like elements at corners and there is no angle of 45° or multiple of 45°. In the second type known as Rsmy Qalib Shaghly, as shown in Fig. **3**, angles of 45˚ and its multiples are used. (Sharbaf, 1372).

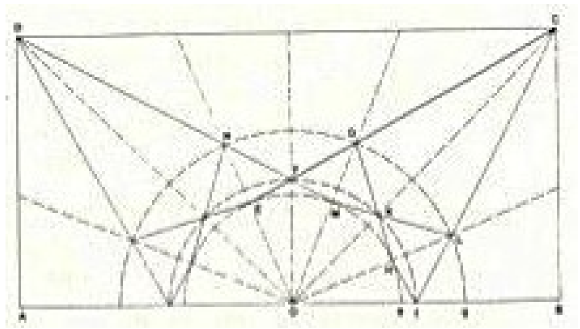


Fig. 2: Example Plan of Rsmy Qalib Srsft; Source: (Sharbaf, 1372)

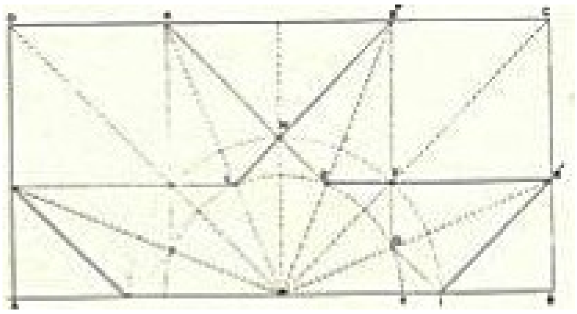


Fig. 3: Example Plan of Rsmy Qalib Shgly. Source: (Sharbaf, 1372)

Identification of karbandis with traditional methods in real-life examples is difficult. A new method for naming karbandis conforming to their main geometrical characteristics was introduced by Mojtaba Pour Ahmadi. The new standard uses a combination of numbers for this purpose. Furthermore, after reviewing and analyzing three main sources on naming Persian karbandis, the new approach was introduced, and its application was explained through some examples (Ahmadi, 2014). His work facilitates researchers with lesser knowledge in Persian architecture. Yazdybandy (یزدی بندی) is a different form of decoration for dome ceilings and is somewhat similar to Rasmybandy. It is different from Karbandy because more horizontal lines are added in Rsmybandy in the horizontal plane besides other elements that are also added to the overall scheme. It also shares, as shown in Fig. **4**, characteristics of self-similarity with fractals.

Rsmybndy evolved in the subcontinent in the form of Qalib Kari in Mughal era. Squinches/Muqarnas, Qalib kari and other stalactite decorations share many similarities in form of geometry and types of elements used.

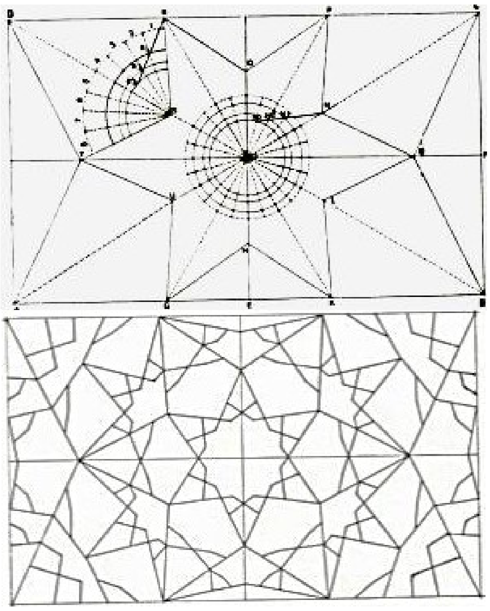


Fig. 4: Formation of Yzdybndy in Plan. Source: (Sharbaf, 1372)

2.3. Treatise and research about stalactite decorations

Early Muslim mathematicians contributed in their own ways to the field of architecture, but Al-Kashi is known to have contributed in writing for construction of this special type of Stalactite decorations that is *Muqarnas*. His book mentioned earlier includes text and figures describing parts of *Muqarnas*.

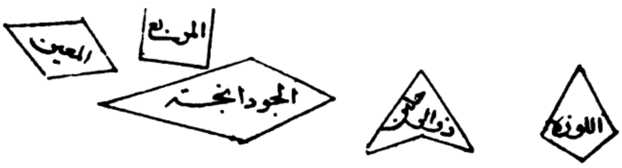


Fig. 5: Elements of *Muqarnas* by Al-Kashi, Source: (Al-kashi,, 1380-1429, p. 181)

Recent researcher analyzed work of Al-Kashi. Elkhateeb in 2012 derived formulas to express forms of both squinches and pendentives and used CAD programs for their modeling. Ho found the relationship of different parts of a squinch or a pendentive (similar to Muqarnas) with the side of cube. Muhammad Al Asad also worked to understand the geometry of Muqarnas and wrote in the journal 'Muqarnas' as well and contributed to the book "The Topkapi Scroll - Geometry and Ornament in Islamic Architecture" by Gülru Necipoğlu in 1995. Yvonne Dold-Samplonius worked with the information put forth by Al-Kashi to understand the geometry of the Muqarnas and produced many papers and a thesis as well, on the subject. These elements formed the basis of stalactite type decorations in the Muslim world and Qallib Kari of Mughal architecture. Other than those elements, star pattern/girih also became an integral part of such decorations. In contrast, Maleki and Woodbury's work is different as it manipulates the parameters of dome-decoration to create similar patterns with different constraints. They used algorithms to research how algorithmically Rasmis can be manipulated, and similar forms can be generated.

Mostly researchers who worked on the Muqarnas or explored interior decorations of domes have either worked on the profiles of domes and vaults or tried to understand the geometry behind the techniques of the construction of these decorations. All the previous research works available deals with the elements and their geometry. These works do not consider the pattern as a whole and miss the virtual geometry/ illusion of formation of a curvilinear flower from straight elements. The following research will understand the geometry of the virtual curvilinear flower formed by the arrangements of the elements already investigated repeatedly. The following case study was selected to understand the geometry of the virtual curve ound on stalactite decorations.

3. Selection of Dome for Case Study

The components discussed earlier also make the part of Mughal architecture. The Authors wanted to select a case study that was prominent of its time and also true representation of Qalib kari. The selected case study is representative of the formation of patterns of the three-dimensional curve on domical surfaces in Mughal architecture. The tomb was built in the seventeenth century by Zeb-un-Nisa (d. 1672). Dai Anga (the Urdu word 'dai' refers to wet-nurse) founded the Dai Anga Mosque in Lahore. Dai Anga's tomb is an important example as it has all works of arts like Kashi Kari, fresco, brick imitation and Qalib Kari. It is considered an exemplary building of Mughal period and is included in the national heritage list of protected monuments. However, it has deteriorated with time, as it was neither protected nor ever conserved. Its architectural crafts and decoration are much appreciated by the scholars. The well-known Lahore-based architect, Kamil Khan Mumtaz, has copied its Qalib Kari for his project of the shrine of Baba Hassan Din. This historical building is a good example of a single-story tomb of the square nine-fold plan type. Though it is not a royal tomb and is smaller as compared to the royal tombs, its decoration is impressive. It has a single central dome with polychrome interior with a small domed pavilion on each of its four corners. All four-corner chambers of the tomb also have domes with similar Qalib Kari (stalactite work) as in the central dome but the scale of these four domes is smaller as compared to the main dome. Design of the main dome shown in Fig. has five circles of interlacing stars, while in the corner domes, stalactite stars complete three circles around apexes of domes. The main dome was analyzed to see the formation of a flower-like pattern in two-dimension.

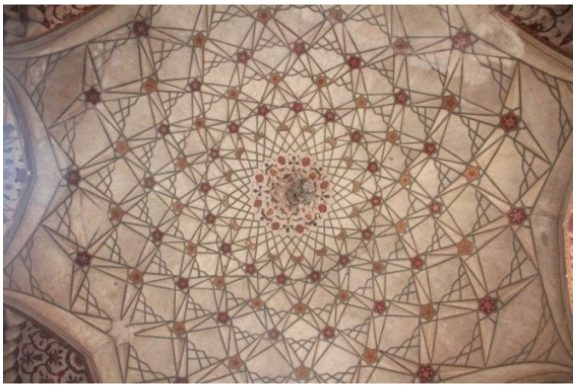


Fig. 6: Main Dome of Dai Anga

4. Different Curves in geometry

Before researching the spiral, the author tested different curves present in the geometry for similarity with the geometry of virtual flower and found no likeness between virtual flower curves and parts of ellipse, hyperbola, and parabola. Other than mentioned curves, the spiral has significance for presence in nature and use in architecture, historically.

4.1. Spiral Types and their Appearance in Nature and Architecture

The appearance of spirals in nature, as well as architecture, is well documented. The nautilus shell, the snail's shell, the ram's horn; the sunflower, the pine cone and the pineapple are such examples. Architects have not only been getting inspiration from spirals but also have been incorporating them in their design for ages (Williams, 1999). Spiral is fundamentally a curve which turns around some central point, getting further away (or closer, if seen in reverse) as it expands outward (Spiral, 2011). The types of spirals, which have attracted scholarly attention most often, include the Logarithmic Spiral, the Archimedean Spiral, the Hyperbolic Spiral and the Cornu Spiral. Other important spirals that make either example cases or characteristics of above-mentioned spirals are the Equiangular Spiral, the Geometric Spiral, the Arithmetic Spiral and the Spiral of Theodorus.

The Equiangular Spiral cuts any line radiating from the center at a constant angle while the geometric spiral requires the distance from the origin/radius to be in a geometric progression. The Logarithmic Spiral, given different names originally, owing to its characteristics, is often the closest to spiral curves found in nature. Golden Spiral, a special case of Logarithmic Spiral, is also closely related to natural occurrences. Fibonacci Spiral, similar to the Golden Spiral, has also been researched for its occurrence in nature. Equiangularity and geometric progression are the first two characteristics of a Logarithmic Spiral. Archimedean spiral, also known as an arithmetic spiral, yields arithmetic progression and this characteristic differentiates it from the logarithmic spiral, which follows a geometric progression. Spiral of Theodorus is a distinctive case that approximates Archimedean Spiral. It is also known as square root or Pythagorean Spiral. The third type is the Hyperbolic Spiral, which is also known as a Reciprocal Spiral and is the opposite of the Archimedean Spiral. The fourth type is the Cornu Spiral curve whose curvature changes linearly with its curve length (the curvature of a circular curve is equal to the reciprocal of the radius) (Magioladitis, 2013)

Greeks used logarithmic spiral in the construction of volute and later renaissance architects also used logarithmic spiral involutes (Williams, 1999). Other than that, a pattern called rosette derived by rotating the similar curves at the center of the circle and then reversing its direction to superimpose upon the first set. One such pattern was discovered on the pavement during the excavations of Pompeii, and dated to the first century B.C. Renaissance architects frequently used rosette in pavement design and the pattern found on the pavement of Florence and Michelangelo is credited with the design featuring rosettes (Williams, 1999).

Kim Williams identified two types of rosette construction in his research. One was logarithmic rosette based on true logarithmic spiral and other was circular rosette based on arrangements of circles that give the illusion of spiral. The latter type is easier than former to construct. There were two major differences between the two types of the rosette. In circular rosette, interstices change both in size and shape according to their location in design. At first interstices increases in size up to a certain limit

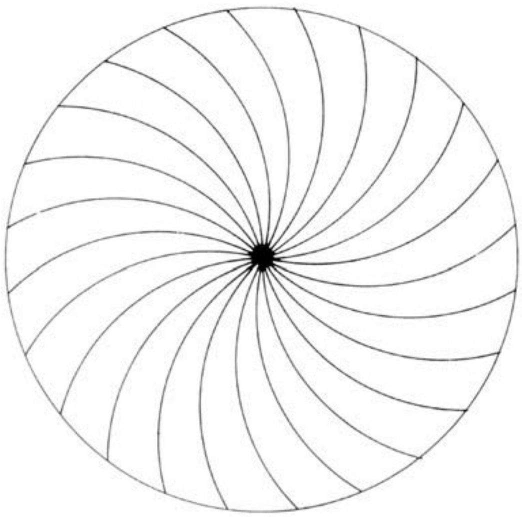


Fig. 7: The fan pattern

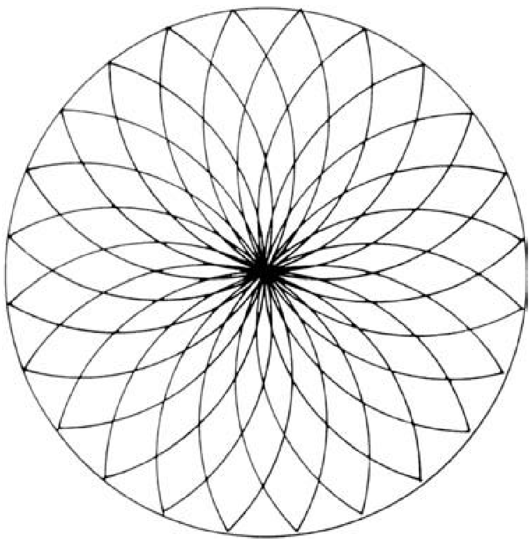


Fig 8: The rosette pattern

then they start shrinking in size after that limit. Whereas when the interstices grow larger as they move further away from the center of the design and remain of the same proportions, then the rosette is based upon a true logarithmic spiral. In the true logarithmic rosette, the interstices do not decrease in size but constantly increase.

5. Analysis of the virtual spiral on the Dome of Dai Anga

Dai Anga's tomb is divided into sixteen equal parts and then arrayed in a circle around the center of the dome that forms a flower pattern showing curves moving away from the center of the dome. Fig. **2**, Fig. **3** and Fig. **4** show and compare the construction of stalactite decorations and interestingly the main units as can be seen in the case study's images meet at the star in the given example. These become the pivot points.

The two-dimensional drawing of the dome in Autodesk AutoCAD was studied to check the type of curve that illusion creates. Though there are other curves like ellipse, hyperbola, and parabola as well, they did not fit well with the drawing when superimposed so those were discarded at an initial stage. Next, different spirals were studied to see if they could be superimposed on a two-dimensional drawing of the dome.

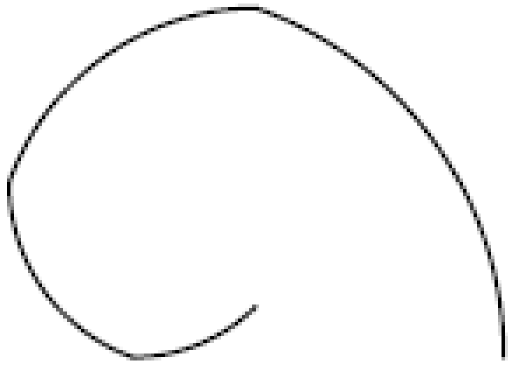


Fig. 9: Spiral Based on √2

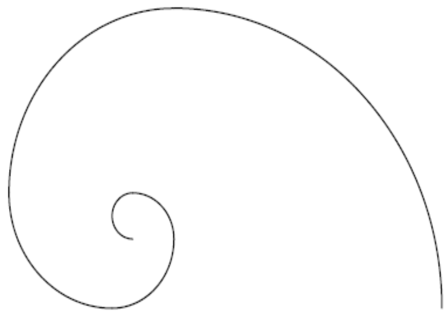


Fig. 60: Fibonacci Spiral

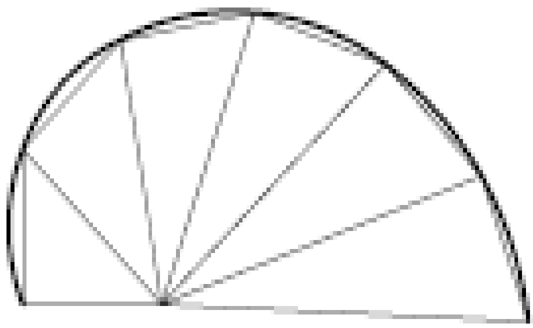


Fig. 11: Spiral of The odorus

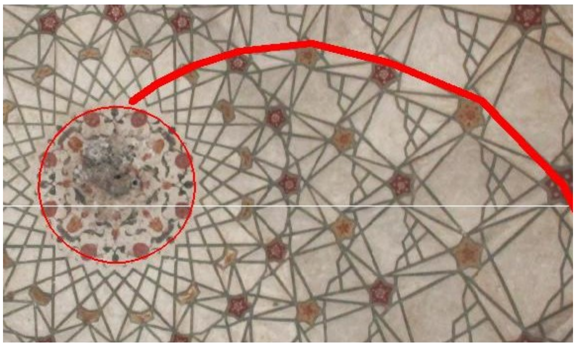


Fig. 12: Virtual spiral of central dome of Dai Anga's tomb

To begin with, three major instances of spirals, common in either nature or works of art, were tested. Golden spiral/Fibonacci spiral is important for its recurrent occurrence in nature. The silver spiral is based on a √2 sequence which is frequently quoted for its use in Islamic architecture. These two are special cases of a logarithmic spiral and follow its characteristics. The third option from preset of four spirals discussed above is the spiral of Theodorus also known as the spiral of roots. It is observed in Greek architecture and is remarkable for use of roots of prime numbers. Considering the importance of golden and silver spirals, they were constructed using AutoCAD for comparison with the dome ornamentation. Spiral based on √2 has very noticeable turns that do not match the growth of dome’s virtual spiral. Golden spiral turns are smoother than √2 spiral but the virtual spiral is different, as the two do not overlap. Apparently, the spiral of Theodorus was little closer to spiral on Dai Anga’s tomb than the other two examples, but its radii were noticeably different from that of the virtual spiral.

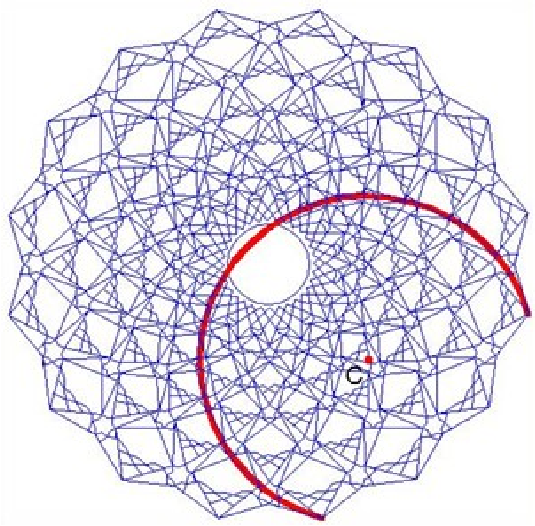


Fig. 13: Arc drawn on virtual curves

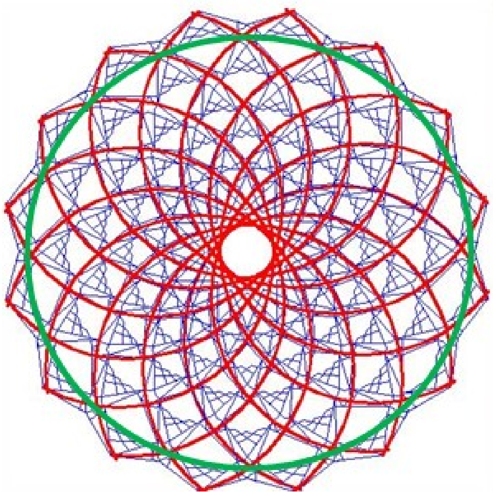
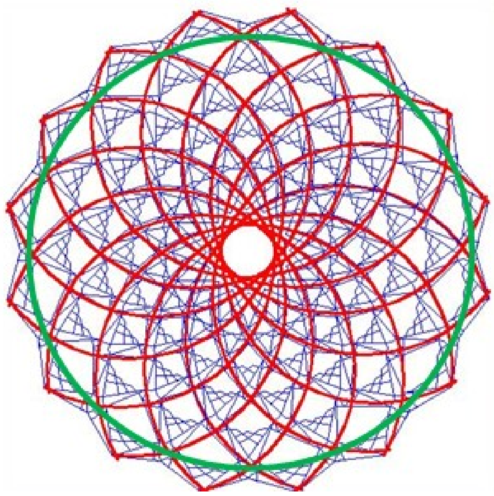


Fig. 14: Rosette based on circles, superimposed on drawing of the Dome

After the unsuccessful attempts of the three famous spirals, an arc was drawn as close to the illusion of spiral as possible to find the probable center point of a spiral. Interestingly, the arc fit quite well on the two-dimensional drawing. Afterwards, that arc was mirrored and arrayed around the center sixteen times to get a flower-like pattern similar to rosette discussed earlier. Each interstice enclosed the elements that were increasing in size while getting away from the center just like interstice. As the dome, curvature meets the straight wall and arches so at the elements take little different shape shown outside the green circle in



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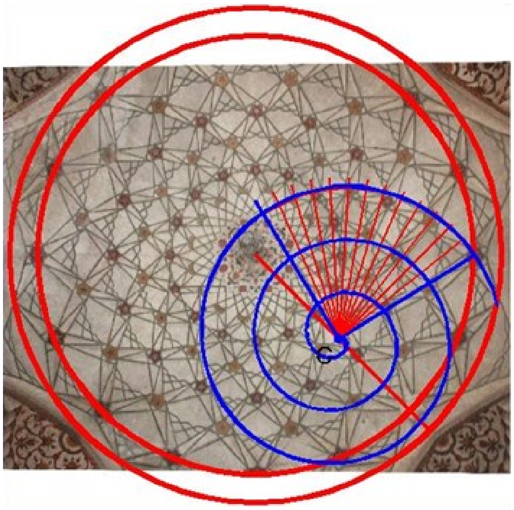


Fig. 15: Logarithmic spiral superimposed on the dome

Later different logarithmic spirals were constructed on the drawing keeping the center close to that of arc superimposed earlier. The simple way to construct a logarithmic spiral is to draw equally spaced rays from the center point of spiral and then starting at a point of the required

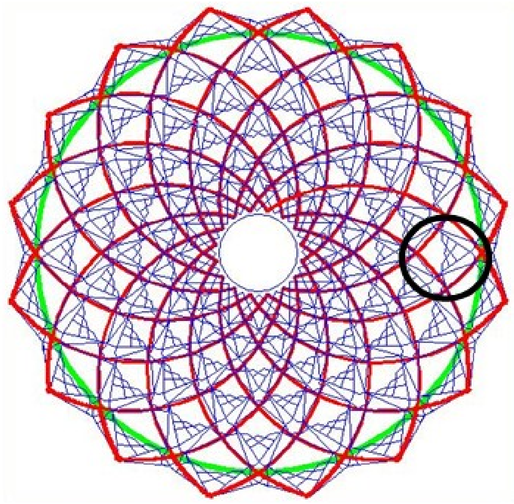


Fig. 16: Logarithmic spirals making Flower like pattern/ Rosette

radius on one ray and keep drawing the perpendicular to a neighboring ray. Infinite rays mean the spiral is a smooth logarithmic spiral (Hilton, Holton, & Pedersen, 1997). Taking this approach of Hilton the part of the virtual curve was divided equally into 8, 10, 12, 14, 16 and 18 parts respectively. Finally, the arc drawn on 14 divisions was true to actual drawing and was chosen to make flower-like pattern or rosette. As is shown in

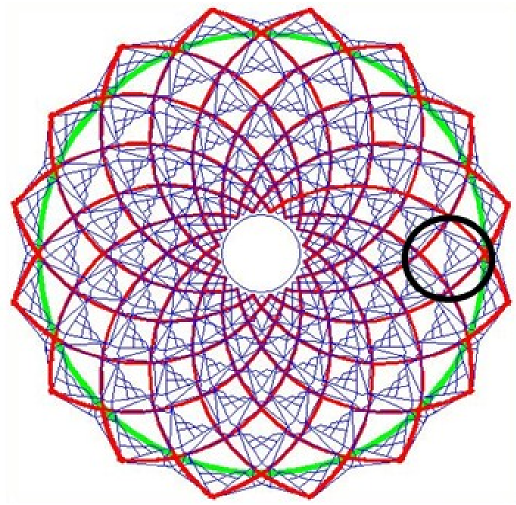


Fig**.** each row has a diamond like interstices that nicely encloses all the elements making one module (enclosed in a black circle in

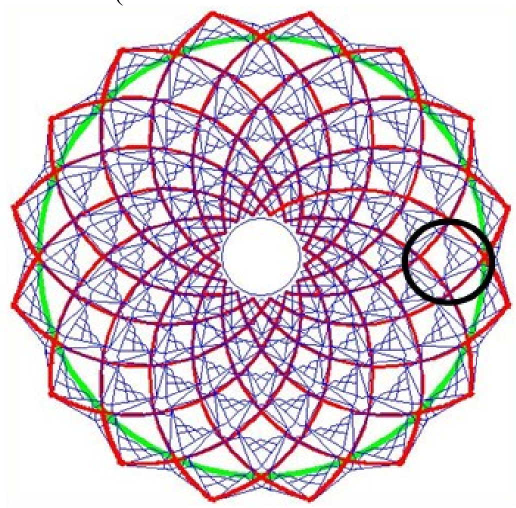


Fig**.**) within the design that grows as it gets away from the center.

Fig. 17: Side/back right corner Dome

5.1. Side-dome of Dai Anga's Tomb

Four side domes of the tomb were smaller in size and three of them completely ruined and plastered whereas, the fourth one on the back was in dilapidated condition as shown in Fig. **17**. Here it is important to mention that dome though smaller in size was similar to the main dome. Although its one-sixteenth part was documented, and all its points were drawn on paper spread down on the floor using plumb line and heights were also measured, the dome was crumbling and there is some margin for error. In this case, also almond and interlaced stars evolve away from the dome center in the form of spirals, both clockwise and anti-clockwise. Intermediary space takes the shape of a kite which also shows a progression. Logarithmic spiral is drawn in AutoCAD as shown in Fig

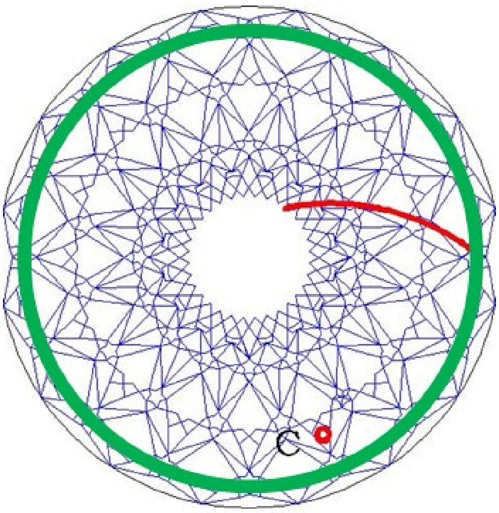


Fig.18: Virtual Logarithmic Spiral on the Dome of Dai Anga' Tomb

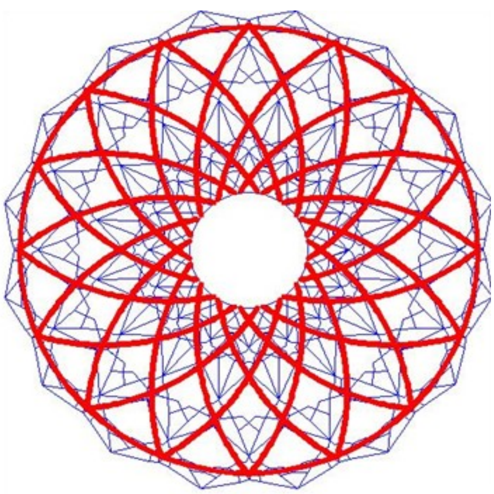


Fig. 19: Division of dome and virtual spiral flower, autocad drawing

Green circle denotes the end of spiral and rest of the part of the dome becomes steeper as the dome connects to its square straight base. This case also showed a close resemblance of the virtual spiral to a logarithmic spiral. In Fig the logarithmic spiral overlaps the elements creating a virtual spiral. In Fig. and Fig. comparison of a model of documented dome and model based on logarithmic spiral is shown. Helix command in AutoCAD was used to draw a 3D helix that was later used for making a 3D model in AutoCAD.

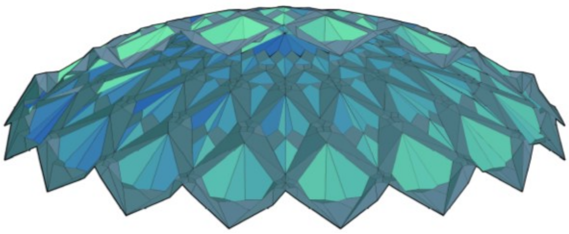


Fig. 20: Actual Model of Dome

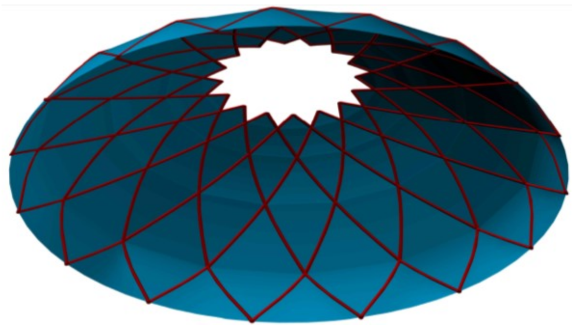
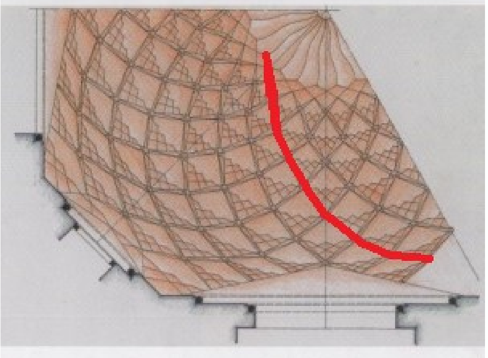


Fig. 21: Model of the Virtual Spiral of Dome which equates with the Logarithmic Spiral

6. Virtual Spiral in other examples from Mughal Architecture

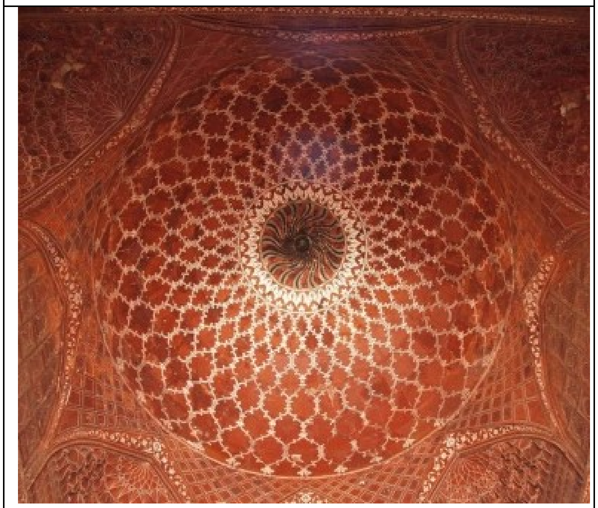
This flower, based on a spiral-like illusion also exists in domes besides the selected case study. These are formed by organizing the basic elements around the center under strict geometrical principles. Taj Mahal, considered an architectural wonder, exhibits the level of mastery achieved by Mughal *maymars* and masons. Interior of the dome of Taj Mahal in India (تاج محل گنبد,هندوستان) is one of the famous examples that gives such an illusion. Outside of India, Iran also has examples of the decoration of domes with illusions of spiral-like formations. This type of construction in Iran continues and the Borujerdi House (خانهٔ بروجردی‌ها, کاشان, ایران) in Kashan, furnishes a nineteenth-century example of a domical decoration showing similar arrangements. The house was named after the owner, a merchant who used to trade with Borujerd in the Lorestan Province of Iran. (Times, 2013). Other than that, Tomb of khan-e-Dauran famous as Buddhu ka Awa shows another example of Virtual Spiral. Another famous Maryam Zamani Mosque shows similar design as discussed in the paper. This part of the paper shows similarity with the main case study. One can see through the images that other than detailed pattern a virtual arc is radiating from the center and guides the eye of the viewer. When combined they also make flower like decorations as shown and discussed in the main Case-Study. However, detailed discussion and Reconstruction of the whole dome is out of scope of this paper as this study focusses on the Tomb of Dai Anga.

Table 1: Other cases with similar Qalib Kari in Mughal Architecture



Curvilinear pattern formation on the interior of Taj Mahal's dome, Source: (Koch, 2006, pp. 131, 176, 187)

Buddhu ka Awa Dome, Source: Self(conservation of Tomb of Khan-e-Dauran)



Taj Mahal Dome, source: Paisley Curtain

BegumShahi MaryamZamani Mosque, source: omaidus

7. Conclusion and future directions

This paper considers the complexity of these patterns as multi-sided. The virtual patterns create variety and complexity to increase interest while repetition at regular intervals creates rhythm. From the info presented above, it can be safely concluded that the Virtual Spiral is based on logarithmic principles. Model of the actual dome, as well as a model based on the spiral, was generated in AutoCAD to discover the close relationship between the two. Up until now, these Stalactite decorations were studied, as a combination of different elements derived from square, as explained in the literature review. Presence of a logarithmic spiral adds to the complexity of the design of these patterns. It also informs on how mathematicians in the Mughal era executed geometric principles observed in nature for ornamentation. In the case study of Dai Anga's tomb, these patterns must have been perceived by those *maymars* in three dimensions in order to form a logarithmic flower and a geometric system most likely used to achieve the desired results. Likewise, the presence of a specific type of spiral also raises questions, e.g what were the guiding principles for the creation of such flower-like virtual patterns. Another aspect that can be explored is the relationship of the spirals with the structure. Furthermore, this information can help in restoration or regeneration of damaged *Qalib Kari* in monuments. The complexity of different, geometry-based, overlapping decorative systems made these patterns mesmerizing and we can use these principles to achieve similar effect. Currently, only Kamil Khan Mumtaz based in Lahore is the only architect who is trying to revive the traditional architecture and we can similar decorations in his work. CAD has provided us opportunity to make such work more common. However, this discussion is out of scope of this paper and author leaves it for future work.

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