Geometrical Model of Relations among Patterns in Iranian Architecture

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Abstract

The relationship between texture, pattern and massing is a fundamental question in architecture. Classical architecture, as Leon Battista Alberti states in De Re Ae dificatoria, is first developed through massing and structure; texture is added afterwards to provide a bold massing and beautiful structure (Rietherand and Baerlecken, 2008: 2). This hierarchy has of course been challenged throughout the history of architecture. Review of the literature shows that most researchers have focused on Islamic ornamentation pattern based on the interior vision, in which the effect of exterior pattern is not considered. This paper will provide a different view of the relationship between massing and texture in Persian architecture through the study of tower tomb in Khorasan, built in Qaznavi and Seljuq era. After that, the effect of ornamental pattern on shaping building structure is considered. Since this research is done based on mathematic and geometric systems, the methodology in this paper is deductive reasoning. One of the main important results of this research is the meaningful relationship between ornamental pattern and structure in Iranian architecture.

Keyword: Hidden and visible geometry, Girih, Ornamental pattern, Structure, Tower tomb

1.Introduction

According to some researchers, the geometrical ornamentations of Islamic architecture appeared as the result of visual bans in Islamic era that led to the tendency of artists towards these patterns. Regarding the geometrical ornamentations of Islamic architecture, people like Ardalan, Bakhtiar, Burckhardt[6], and Nasr have conducted studies on their metaphysical aspect; and others, such as Cromwell[7] and Critchlow[8], have studied their mathematical and geometrical aspects, through which the deep knowledge applied in the architecture of Iranian buildings can be revealed (Kharazmi, 2013: 14). Islamic historians like Beihaqi, Ibn-e Khaldoon, and Khajeh Rashid Aldin have noted useful ideas about architecture and architects, including the fact that architects had been aware of mathematics and geometrical science and considered planning and design before building any structure (Kiani, 1997: 23).

Regarding Horror vacui (fear of vacant spaces), in his book "*the Sense of Order*", Ernst Gombrich questions the designers' incentive to load any unloaded space by designing complex patterns He finds this commitment as the architects' willingness to eternity and their amour infiniti[11] (love of infinity).That is why the plain spaces are continually filled with more and more complex geometry. He claims that classical architects applied ornamentations to fill the vacant spaces, and these steps had been paved by considering a predefined framework or border. Therefore, modeling had been in connection with a predefined structure. Gombrich calls these rules graded complication[12], where a border is defined more extensively after the previous one and gets more complex in a gradual procedure. Instead of applying this approach of decoration and graded filling of a pattern within predefined limits, Iranian architects have offered a different relation among texture, structure, and massing (Rietherand & Baerlecken, 2008: 2). *Girihs* can be twisted in themselves and continued; it may show that a pattern may not only be used as a texture for the facade, but also the general view of a plan and facade can be the footprint of a pattern in a very larger scale. If this issue gets approved, it means that the pattern's model is formed in the hidden and 2-dimentional geometry in the process of building a structure. Then, space and massing are revealed in a 3-dimentional form based on this hidden geometry. It means that base plans and facades were derived[13] from the logic and hidden geometry of patterns and *Girihs*. Then, they were extruded[14] in vertical and horizontal dimensions to create massing and space. In this study, it is attempted to investigate the relationship between the hidden geometry of pattern with plan and the general structure of buildings in pylons and tower tombs through analyzing the drawing methods of this hidden geometry of patterns and Girihs on the body of the building.

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Research objectives

- Investigating the relationship between structural patterns and ornamental patterns in tower tombs in Seljuq and Qaznavi eras in Khorasan.
- Explaining the meaningful relationship between the pattern model and texture with structures in tower tombs' architecture in Khorasan.

Research questions

1. Is there a relationship between ornamental patterns and structural patterns in Iranian architecture (pylons & tower tombs)?
2. What is the relationship between ornamental patterns and structural patterns (how was the relationship between texture and structure in the architecture of pylons and tower tombs in Seljuq era in Khoasan?)

Research hypotheses

- There is a relationship between ornamental pattern and structural pattern in Iranian architecture (tower tombs).
- There is a relationship between the hidden geometry of pattern and texture (Girih pattern) with structure of plan in tower tombs of Qaznavi and Seljuq eras in Khorasan.

Research Method

The research method is Logical reasoning combined with case study. Logical reasoning is a kind of dynamic recognition, a movement from basics towards outcomes. This movement entails several steps and involves a gradual and constant movement (Mirjani, 2010: 38). Deductive reasoning is basically a relational process, meaning that the mind starts its movement from the basics towards the outcomes through connecting to the previously learned knowledge. In other words, making connections is the origin of a wider movement in the process of deductive reasoning (Ibid. 39). Groot and Vang introduced the main components of deductive reasoning as follows (which are also used in the following steps of this study):

1. Definition: Due to the innovative nature of the preliminary systems and their paradigmatic status, they introduce a list of technical words (Golestani, 2017: 32). This study also enjoys the review of the standpoints of some specialists in this area to extract the specialized vocabularies and definitions. Then, the researcher reintroduces and redefines these words and definitions based on the present study's form and context.
2. Relation: After clarifying the definitions of specialized vocabularies, a systematic framework of the relation between assumptions will pave the way to achieve a logical system (Groot & Vank, 2005: 322). Subsequently, a precise geometrical analysis will be done on the samples based on the drawing methods and the geographical systems of the same era. The research hypotheses will be tested on the samples.

3. Expression: In this step, the concepts are conveyed to the audience with the help of some tactics (Ibid. 322). Here, the significant relation between ornamentation and structure will be investigated using specialized software.

Literature review and research background

Considering the previous comprehensive studies, the present study consists of 3 parts (diagram 2). There are many studies on Khorasan architecture in Islamic era, including Bernard Ovkin (2007), Fry[15] (2008), Gholamreza Naeema (2015), Ghofrani (2008), Graber (2000), Labbaf Khaniaki (2010), and many articles that are mentioned in the reference section. Among the recent studies on geometrical ornamentations, one of the best studies is the book written by Golroo Najiboqloo (2010). In chapter 4, part two of the book, the entire studies and books about geometrical Islamic patterns are reviewed and Girih has been evaluated in terms of different aspects, like geographical, historical, and semantic aspects. Books such as "the design and the drawing of patterns in Iran's mosaic work in Islamic era" (Maher Alnaqesh, 1982), Girih tiles in Islamic architecture and handicrafts (Zomorshidi, 1986), and Girih and *"Karbandi"* (She'rbaf, 2006) are instances of valuable local works. There are creditable studies on the mathematics applied in Islamic ornamentations. In her book "Geometry and Ornamentation in Islamic Architecture," Najiboqloo (1996) evaluates Toobqapi scroll[16] and points to the practical use of geometry in architectural ornamentation. In the article "*mathematics and art: the link between theory and practice in Islam*", Oz Dural[17] (2000) posits that according to the treaty "the required geometry by craftsmen" by Abol-vafa Boozjani, the cooperation between mathematicians and architects for creating geometrical Girihs can be discovered. Kharazmi carried out a study entitled "a reflection on the flourish of practical geometry in Islamic era (Boozjani treaty) in Khorasan's architectural ornamentations based on Gonabad mosques (Malek Zozan & Feryomed)" and explained the meaningful relationship between the developments in the science of geometry with evolution and the complexity of geometrical ornamentations of Khorasan architecture. Also, the study by Navaee and Haji Qasemi (2011) uncovers the hidden geometry of plan and facade to find the common order in various parts of a building. Among these studies, little attention is paid to the relation between pattern model and the general structure of the building. In most of these studies, the pattern model has been evaluated in isolation and independent of its context. This may be due to the complicated and broad nature of geometrical patterns. In this study, the relation of pattern with other parts of the building will be evaluated to see whether these

patterns were just a layer for ornamentation or a means to give the building a more effective impact.

1. Geometrical pattern or *Girih*[18]

Geometrical pattern, also called "*Girih*" by specialists, is a branch of Islamic patterning art. The presence of *Girihs* in traditional buildings emphasizes order in these buildings (the order that was created through the use of pure forms, central and radial orders, symmetry and other devices) and manifests the building as a display of order and geometry (Navaee & Haji Qasemi, 2011: 176). *Girih* catches the eyes. This quality is the result of rotative nature of *Girih* pattern[18] in various circles and specified hierarchy around the central pattern, called "*Shamseh*". *Girih* patterns, while in congruency with each other, have their own character and independence; each of them has a name based on which the form, angle, and size ratios in that pattern are specified. The form of a part in a *Girih*, in a wide range, may consist of many other parts (Ibid.176). This feature shows each part as a whole and reminds the principle of similarity between part and whole in Iranian architecture. In fact, this study seeks to find the part to whole relation, a part that forms the whole[20] itself. *Girih*s can be seen in various frames of various sizes, portions, and forms. Each *Girih* can be placed in various frames. Regarding the conformity of *Girih* to frame, it should be noted that *Girih* does not change its uniform and fixed form to conform to the frame, but it is the frame that has to inevitably change its form and dimensions to conform to *Girih*[21]. *Girih* has 2-dimensional and 3-dimensional forms, all of which are created from similar sub-patterns (Tavakoli, 2016: 15). Therefore, *Muqarnas* is a kind of *Girih* (She'rbaf, 1998: 32). In the present study, the sub-patterns designed to create the main pattern of *Girih* are called hidden geometry and the main and visible patterns are called visible geometry. Also, 2-dimensional or visible 3-dimensional visible geometry is formed according to the place where this geometry is implemented.

2. Definition of Tower Tombs and Pylons

The statement "architecture started from ornamenting the cemeteries" (Dorant, 1993: 20) points to the significance of graveyard's environments. Generally, a tomb refers to a place where some religious or political figures are buried. Constructing sepulchral buildings in the form of constructing glorious tombs over the grave of religious leaders, kings, and famous people became popular during post-Islam period in Iran. In Seljuq era (5-6 century AH), building tower tombs, as a kind of religious building, became very popular and making tombs with various plans became widespread in Seljuq territories (Moshabaki, 2018: 1). Poop considers tower tombs as the most important tombs and deems symbolic notions for a grave's components (Ibid. 27). The fifth century AH had a large set of Iranian cylindrical brick pylons. There was such a great

certainty in their visual quality that their spread was a matter of inevitability (Brand, 1999: 192). These high-rise pylons that reach 100 feet height[22] express their symbolic function based on their location[24] and the special attention given to their external facade.

3. Definition of ornamental and structural patterns

Pattern models are considered as a bridge between theoretical concepts of life and practical concepts of place (Alexander, 2002: 134). Diagram 4 shows the overall relation of patterns. There are structure-making patterns in this diagram that appear at the beginning of the pattern's spectrum. Then comes lower-scale patterns, which are more valuable and are considered as the components of these structures. After that come the patterns that appear at the end of components' spectrum that ornament the structure of patterns bigger than themselves (Salingors, 2008: 90). In this study, by structural pattern we mean the overall and normally hidden order that coordinates the whole components of the building. The real instance of them is viewed in cases of hidden 2-dimensional geometry in the main structure of plan and the general structure of the building's bulk and massing. In fact, they are the geometry and the main order that form the structure of massing (the hidden and visible geometry of plan, form and building's bulk). Ornamental patterns are the patterns that ornament the structures and are infinite in Iranian architecture. The ornamental patterns in this study are considered as the hidden and visible geometry of current Girihs in the Research scope (the geographical and mathematical systems of ornaments in Seljuq and Qaznavi era). Texture and geometrical patterns of the facade include Girihs, structure's motif, and the hidden geometry of Girihs.

4. Research scope and case studies

Data collection method in this study is based on library and documentary studies as well as observations, visiting and fieldwork. The research population in this study is the set of documents related to research questions. These documents are valuable architectural works that will be analyzed. The entire buildings that fall within the specified time and location are tested here (the entire pylons and tower tombs in Qaznavi and Seljuq era in Khorasan region). Factors affecting the selection of research scope are:

1. Referring to the sources of Islamic architecture
2. Preparing analogical parameters for the selected works
(Parity in geographical territory: All samples are located in Khorasan.
Temporal parity: Seljuq and Qaznavi eras, Razi style
Architectural parity: The buildings have symbolic nature: pylons & tower tombs)
3. The possibility of direct access to study the work

5. Data Analysis

Hypothesis testing on each building includes 5 steps:

1. Finding the name and type of *Girih*, the type of brickwork on the facade and the ceiling of the building, and discovering common geometrical patterns in Seljuq pylons.

2. Discovering and drawing the hidden and visible geometry of *Girih* and evaluating the process of pattern formation.

3. Discovering and drawing the hidden and visible geometry of plan and evaluating the process of plan formation.

4. Hidden and visible geometries were drawn in two steps. In the first step, it was drawn applying the drawing device of its own early era (i.e., ungraded ruler and a compass). In the second step, it was drawn by applying software.

5. Discovering the relations among the hidden and visible geometry of *Girih* and the hidden and visible geometry of plan and bulk using software.

To pave the above-mentioned steps, the relations are first perceived and discovered, and then, the analysis will be done. To have a better understanding about the steps of hypothesis testing, two cases of buildings are fully explained (a pylon and a tower tomb[25]).

5.1. Sangbast complex (Ayaz tomb and pylon)

There are various patterns on the brickwork ornamentation of this complex. One of these patterns are *Shamse* and *Bazooband* pattern on *Girih*. The effect of the geometry of this pattern on Ayaz tomb and pylon's plans will be evaluated.

5.1.1. The formation of ornamenting pattern: "*Shamseh* and *Bazooband*"

Steps of drawing Vagirih are as follows: (figure7)

5.1.2. Analysis of Ayaz pylon and tomb

Steps of analyzing Sangbast Complex are as follows: (figure 8,9,10)

5 .2. Aliabad Keshmar Tower

First, the ornamental pattern (on the ceiling) of this building is investigated.

5.2.1. Formation of ornamental pattern: "*Rasmi 28 in the small & big 8 background*"

The steps of drawing "Rasmi 28 in the small & big 8 background" are as the followings: (figure 11)

5.2.2. The analysis of Keshmar Tower

Keshmar tower has a geometrical plan of 16 sides. In this section, the relationship between hidden geometry of complex pattern (Rasmi 28 in small & big 8 background) and the geometry of plan. The steps are as the following: (figure 12,13)

Research Findings

Research findings showed that in geometrical language of Girih, lines and angels could be expressed in the form of Scale Units by numeral proportions. These measurement Scale Units convert conceptual algebraic equations to rational geometrical relations in Girihs, which result from equal division of square and rectangular Vagirihs into similar or uniform twisted forms in the light of observing the rules of geometrical expansion. Using proportions was a significant element in practical geometry books. The tactics of indirect measurement are based on proportions that emphasized finding the proportion of an uncertain quantity based on a certain quantity. While conforming the hidden geometry of Girih to plan's geometry, it became clear that the proportions applied in each Girih unit were also equally observed in plan. Also, it was found that the joint points of Vagirih in hidden geometry of Girih in plan have a function like the entrance, or it has a form like protrusion and depression in plan.
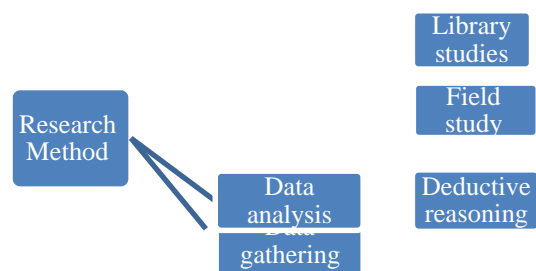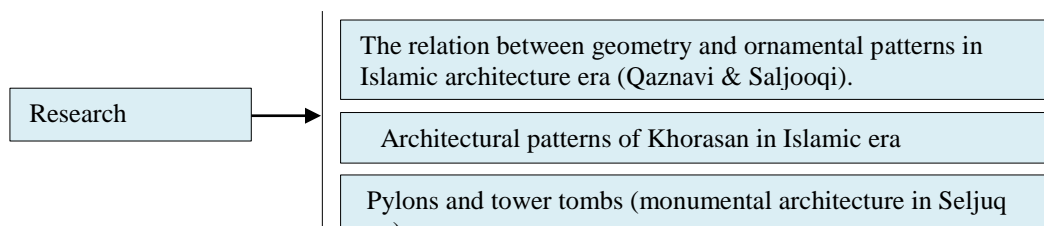
Diagram 1: research method (research findings)
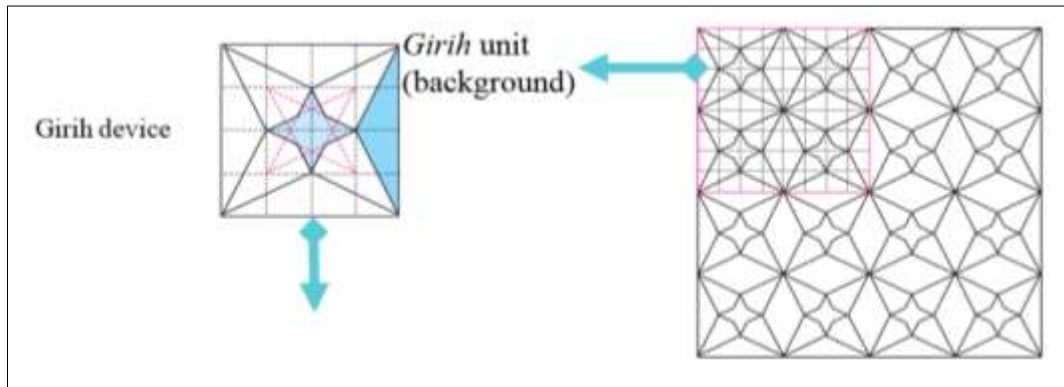

Diagram 2: Research backgroun

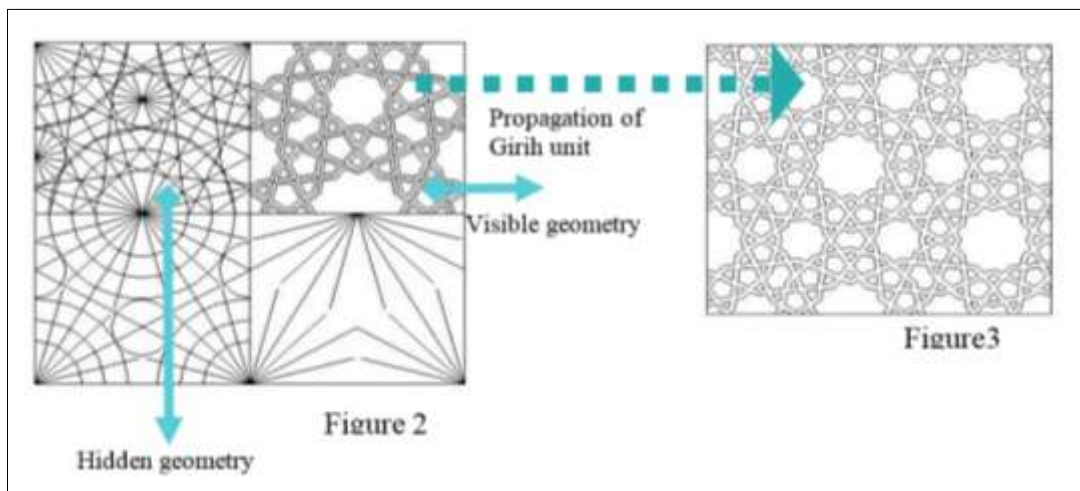Figure 1: Components of Girih (diamond Girih, 4-sided Girih) (Drawn by the researchers)

Figure 2: The process of converting the hidden geometry to visible geometry (Drawn

Figure 3: Visible 2-dimentioal geometry (Drawn by the researchers)

Figure 4: Radkan pylon (Chenaran)

Figure 5: Khosrogerd pylon in Sabzevar
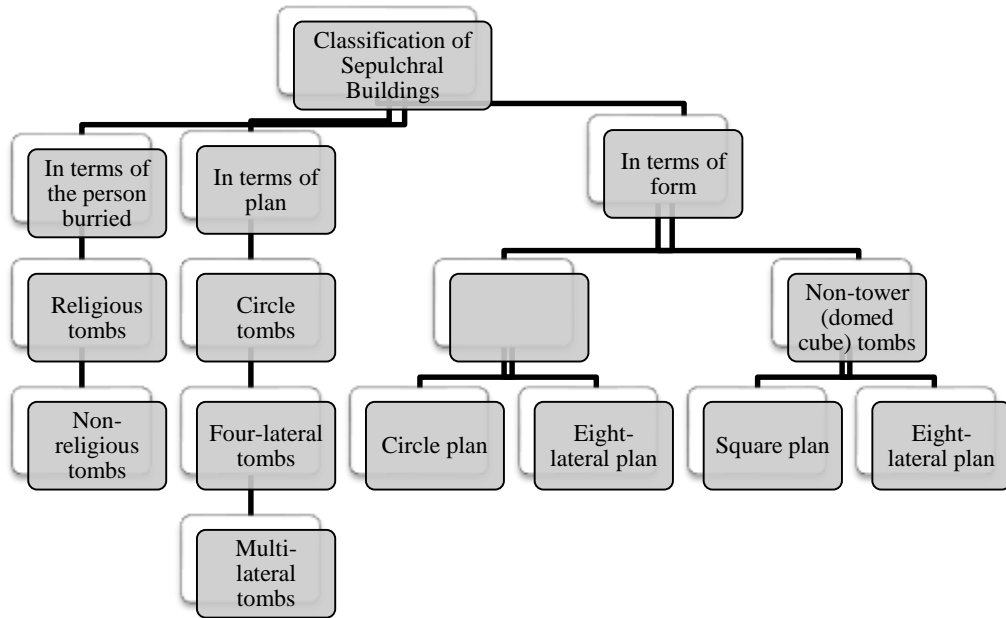
Diagram 3: Classification of sepulchral buildings

Diagram 4: General diagram of the structure, the relation of patterns to each other,
and the importance of their precedence to each other in a spectrum (Salingors, 2008: 90)
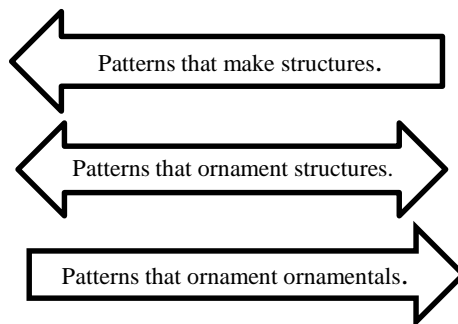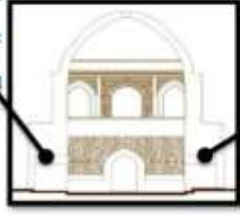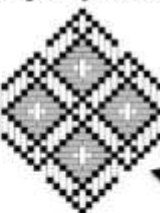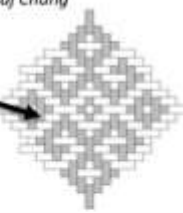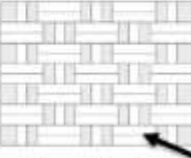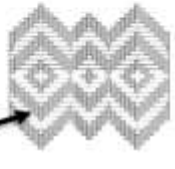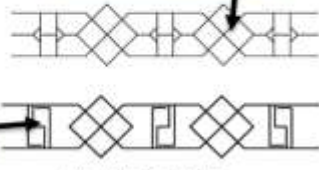
Table 1: introduction of buildings in the research scope

Name	Geographical location / Historical period	Ornamental pattern on the façade in the form of Girihs and brick
Sangbast complex (Ayaz tomb and pylon)	Khorasran Razavi Fariman / Qaznavi era (Razi style) 389-421 AH	"hasht & char lenge" "Shamse Bazoobandi"
Khosrogerd pylon	Khorasran Razavi (Sabzevar) / Seljuq era (Razi Style) 5-6 century AH	"Moagheli Joft Cloobandan Haft Raj" "Magheli 5 Raj Chang"
Radkan pylon	Khorasran Razavi (chenaran) / Seljuq era 679-700 AH	"Hasirbafbaz" "Khefte Raste Bargardan"
Aliabad Tower	Khorasran Razavi Kashmar / Seljuq era/ Razi style 7th century AH	"Kolook Gardan Haft Raj" "Khefte Raste Bargardan"
Karrat pylon	Khorasran Razavi (Taibad) / Seljuq era/ Razi style 7th century AH	"Hasht & Tabl Moj"

The cross section of Sangbast tomb

" *Shamse and Bazooband*" patterns in façade of the tomb

Repetitive module

45-degree rotation of Girih
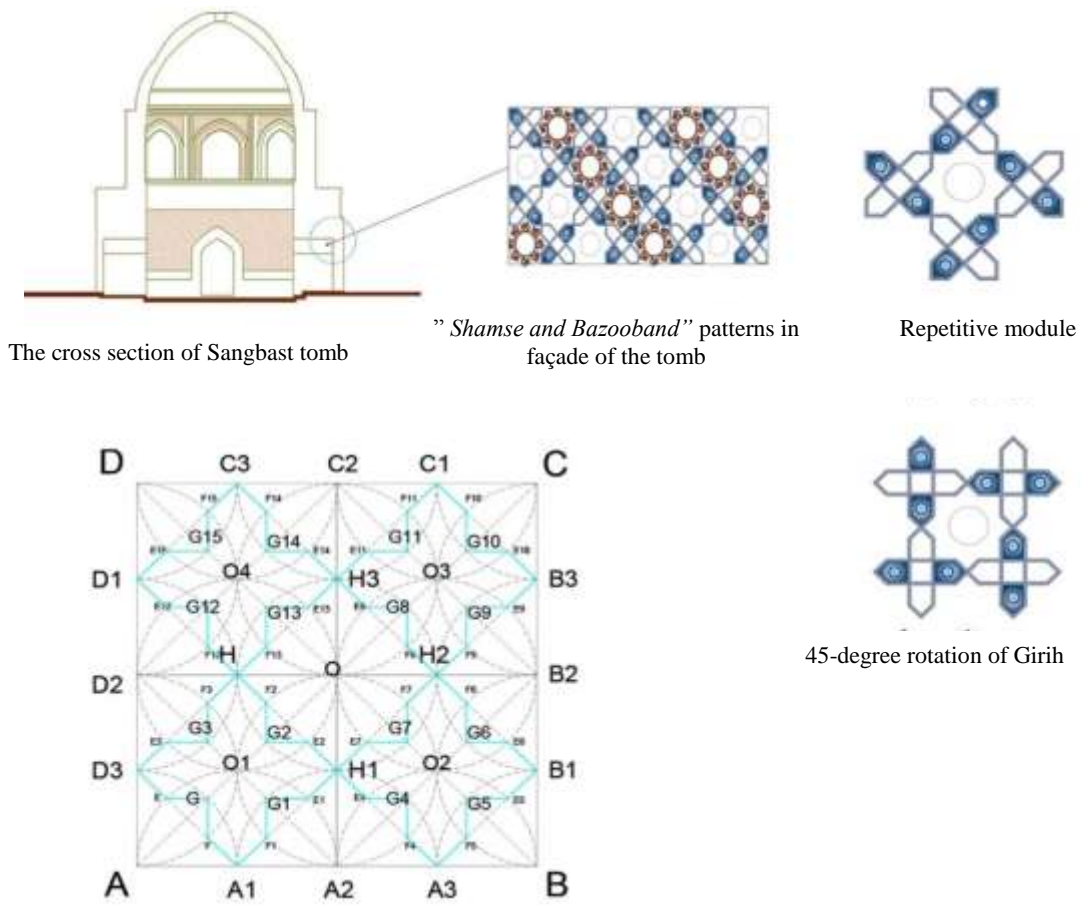
Figure 6: A Display of visible and hidden geometry of a Girih unit and nomination of its various components

Step 1: draw a square (ABCD) in an arbitrary size, draw its diameters, then connect the middle points of neighboring sides to each other to obtain A,B,C,D square.

Step 2: draw an arc around A,B,C,D as centers to cut the diameters in G1, G2, G_3 and G_4 points.

Step 3: draw an arc around A_1, B_1, C_1 and D_1 as centers to cut the sides of A_1 $B_1C_1D_1$ square at E_1, E, F_2, E_3, E_2, F_3, F_1.

Step 4: connect E and F points to G, then connect E_1, F_1 to E_2, G_1 and finally connect F_2 to E_3, G_2 points; and connect F_3 to G_3.

Figure 7

Figure 8

Figure 9

A- The geometry of Ayaz pylon's plan can be obtained through the following steps:

1. Drawing a circle of OH radius; this is the central geometry of the plan.

3. Connecting E, G lines and their sub-lines to draw GG5G10G15 square as the central square of the plan.

4. Connecting E_7, G_8, G_{13}, F_{13}, F_2 and G_2 lines perpendicular to ABCD square to create G_8J_1, H_1J, $G_{13}J_2$, $F_{13}J_3$, F_2J_4 and G_2J_5 lines. These lines along with BC, JB, CJ$_3$ make the overall geometry of plan. (figure 8)

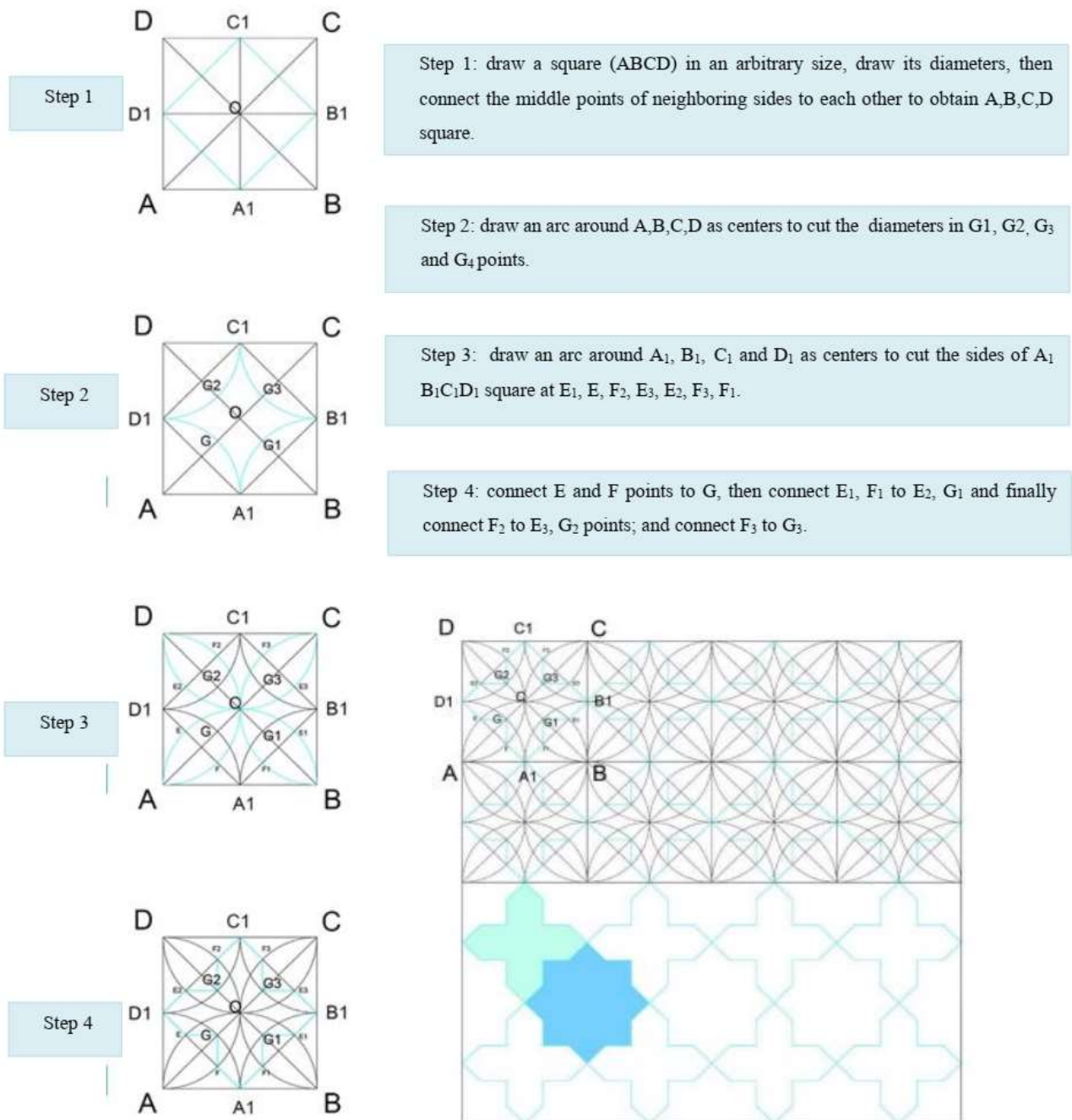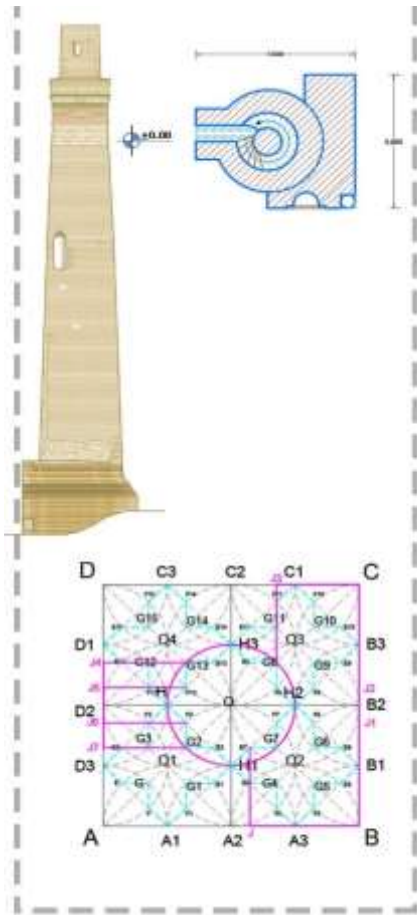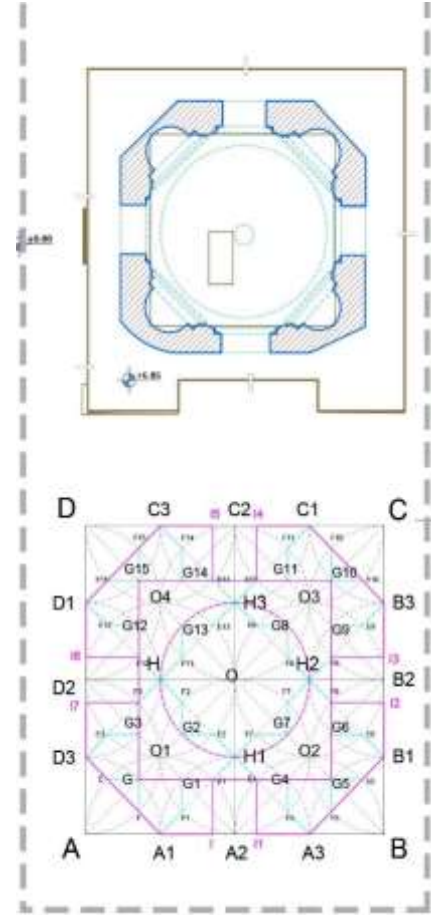B- The geometry of tomb plan on 1 m height can be obtained through the following steps:

1. Drawing ABCD square.

2. Drawing a circle of OH radius. This is the central geometry of the plan.

3. Connecting E, G lines and their sub-lines to draw GG5G10G15 square as the central square of the plan.

4. Connecting E_1, E_4, F_6, F_9, E_{11}, E_{14}, F_{12} and F_3 lines perpendicular to ABCD square to create E_4I_1, E_1I, F_6I_2, F_9H_3, $E_{11}I_4$, E_{14}, I_5, $F_{12}I_6$ and F_3I_7 lines. These lines form the entrance of the building on the plan. (figure 9)
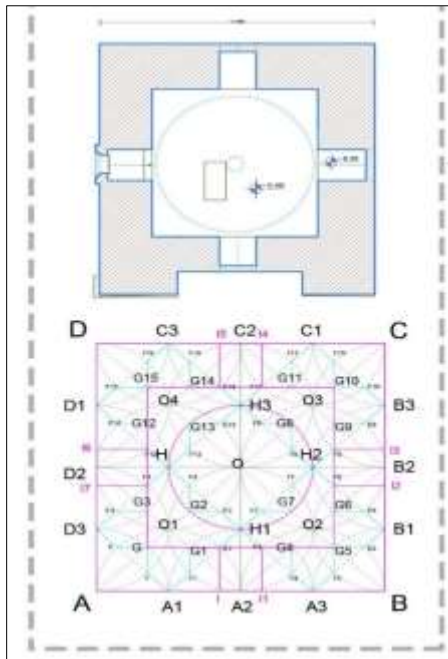
Figure 10

C- The geometry of the tomb's plan and ceiling on 6 m height can be obtained through the following steps:

1. Drawing the geometry of an octagon as the sidewalls of the plan by creating A_1A_3, B_1B_3, C_1C_3, and D_1D_3 lines.

2. Drawing a circle of OH radius. This is the central geometry of the plan.

3. Connecting E, G lines and their sub-lines to draw GG5G10G15 square as the central square of the plan.

4. connecting E_1, E_4, F_6, F_9, E_{11}, E_{14}, F_{12} and F_3 lines perpendicular to ABCD square to create E_4I_1, E_1I, F_6I_2, F_9H_3, $E_{11}I_4$, $E_{14}I_5$, $F_{12}I_6$ and F_3I_7 lines. These lines form the entrance of the building on the plan. (figure 10)
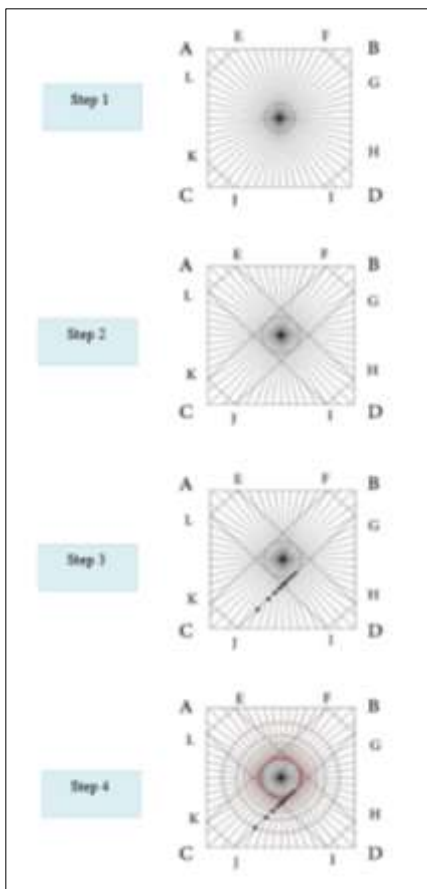
1. A rectangle is drawn (ABCD) to depict this "Karbandi". Then, its background is divided into 56 equal parts and the EFGHIJKL octagon is delineated in this background.

2. GJ, KK, EH and LI points are connected to each other to characterize the size of the middle *Shamseh*.

3. GJ, KK, EH and LI segment lines cut the dotted line in different points. For instance, the GJ segment line crosses the dotted lines of background and creates points like the ones in figure 3.

4. From the center of the circle, more circles are drawn with the radius of each of these points. Therefore, bergamots get completed by common pens in any angel.

5. In the final step, *'Rasmi* 28 in small & big 8 background" becomes clear.
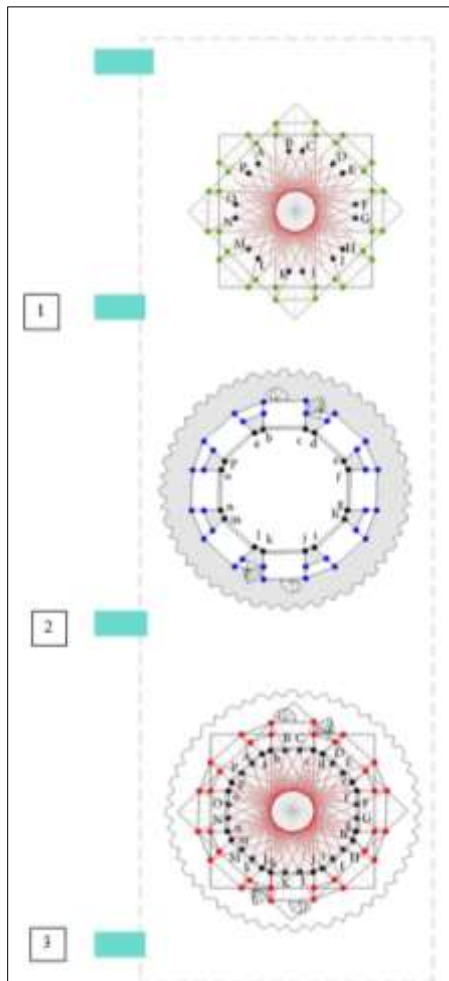
Figure 11

Figure 12

1. The plan of geometrical Girih of "Rasmi 28 in small & big 8 background".
2. 45 degrees' rotation of the plan of geometrical Girih of "Rasmi 28 in small & big 8 background".
3. The composition of two geometrical Girihs of 1 & 2.
4. Aliabad tower's plan.

Figure 13

5.2.2. The analysis of Keshmar Tower

Keshmar tower has a geometrical plan of 16 sides. In this section, the relationship between hidden geometry of complex pattern (Rasmi 28 in small & big 8 background) and the geometry of plan.

1. First, the effective points of Girih geometry and plan geometry are marked. These points include A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P and the green points.

2. The common points between the geometry of building's plan and Girih are characterized on the plan. These points include a, b, c, d, e, f, g, h, I, j, k, l, m, n, o, p and the blue points.

3. Then, Girih plan is conformed to the building's plan. Here, it can be seen that the marked points of building's plan coincide with the ones on Girih plan. Hence, these common points are marked red.

By drawing a line from A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P points in a vertical direction toward the red points on Girih plan, *ef, cd, bc, mn, kl, ji, gh,* and *op* will be obtained.

Model 1: the relational model of geometrical patterns in the research scope

Table 2: The way ornamental patterns affect structural patterns

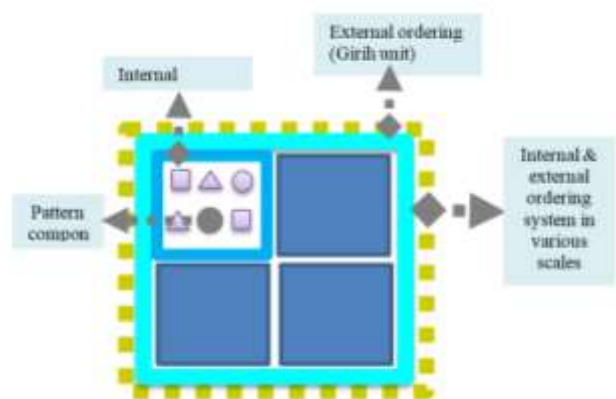| The effect of ornamental pattern on plan structure	Hidden geometry / Visible geometry	Type of Girih	Plan	Name
		"Shamseh Bazooband"		Sangbast complex
		"Hasht and Tabl Moj"		Khosrogerd Pylon
		"Rasmi 28"		Aliabad tower
		"Pili" with the base of square		Karrat pylon
		"Rasmi 28"		Radkan tower

Conclusion and recommendations

The spatial and planar geometrical patterns that had been left next to each other in Scrolls[26] verify the claim that these two arrangements are complementary. This notable connection had been neglected in the studies on ornamentations in Islamic architecture for a long time. Subsequently, this has led to the ignorance of the effects of 3-dinenssional patterns. The result of this study verifies Boolat Huf's [27] opinion, who posits that the direct transferability of 2-dimenssional and 3-dimenssional geometrical patterns is a sign of unity and harmony in Islamic architecture, a unity among the symmetrical system of plans, walls, and decorative niches. This dynamic dialogue of planar (2-D) and

spatial (3-D) geometry makes Iranian architecture harmonious.

Here, research questions are reviewed and replied:

1. Is there a relationship between ornamental patterns and structural patterns in Iranian architecture (pylons & tower tombs)?

The results of hypothesis testing on the sample buildings showed a strong and meaningful relationship between ornamental pattern and structural pattern. The results of analysis showed that the formation of plans and facades are based on *Girih's* pattern (in fact, plan and facade are the hidden geometry of *Girih* that have found dimensions in vertical and horizontal directions to create form and space). Therefore, it can be claimed that texture and pattern were first formed in the pylon and tower tomb's architecture. Then, then massing and structure were made based on them. This finding is exactly contrary to Alberit's theory about cycle and sequence in design process (the hierarchy of the formation of a building's components).

2. What is the relationship between ornamental patterns and structural patterns (how was the relationship between texture and structure in the architecture of pylons and tower tombs in Seljuq era in Khoasan?)

It was tried to find a different relationship between texture and massing in Islamic architecture in this study. The formation of pylons in Seljuq era had followed a specific geometrical and mathematical system. Ornamental patterns, which are considered as geometrical structure of texture and ornamental forms, have been effective in the formation of plan structure (table 2). This effect shows that geometrical patterns in Islamic architecture have been something more than ornamentations. These patterns express a powerful geometrical system in harmonizing the entire components of the building, so that the ornamentation and structure adhere to the whole and hidden order; this hidden order gets visible through the discovery of hidden lines and points in the geometry of *Girih*. The patterns were not just a layer for decoration, but they had a deeper impact on the building's structure.

Discovering a Common Geometrical Language & a Common Geometrical System

Another considerable point in the steps of depicting the pattern and sub-patterns is that besides the fact that the formation and drawing of plan structure has been based on pattern model, the practical content of plan is also influenced by *Girih* components. When the common points between plan geometry and pattern were found, it became clear that the significant points in geometry of a *Girih* unit were also meaningful in plan; for instance, a point in *Girih* that is the result of *Vagirihs* interface plays an important role in the visible geometry of *Girih*. It is deemed as entrance in a plan. This concurrent formation of ornamentation and structure is validation of research hypothesis. Finally, a considerable note that can led the way to further

studies is that the strong relationship between ornamental patterns and structural patterns in case study samples clarifies that while modeling patterns of Islamic architecture, it is noteworthy to know that in Iranian architecture, a pattern has various translations in different scales; and all patterns are linked to each other by the hidden chain of geometrical system. Therefore, it is inadmissible to copy a pattern without considering the relation of that pattern to other patterns.The purpose of all systems, either implicitly or explicitly, is to compile professional standards of designing. This study tried to analyze the structural geometry of the entire components of the building through clarifying the part to whole relation and testing this relation in samples of landmarks (pylons and tower tombs in Qaznavi & Seljuq era in Khorasan region). It also tried to uncover the origins of this geometry as a consequent of pattern, which can be a fine exercise to design landmarks and monuments.

Postscripts:

1. Texture
2. Pattern
3. Massing
4. Alberti, L. B.
5. Alberti, L. B., *De re aedificatoria, On the Art of Building in Ten Books*, (translated by Joseph Rykwert, Neil Leach, and Robert Tavern or), MIT Press, Cambridge, Massachusetts, 1988.
6. Burckhardt
7. Cromwell
8. Critchlow
9. Ernst Gombrich
10. Horror vacui
11. Amour infiniti
12. Graded complication
13. Derived
14. Extrude
15. Fry
16. Scroll: it refers to a set of ancient studio maps that architects considered them as secret documents and kept then private. The scrolls were as entries to secret worlds of practice in architecture and ornamentation (Najiboqloo, 1389, p. 11)
17. Oz doral
18. Making Girih is called "architect's chess" by traditional craftsmen of Iranian architecture.
19. Vagirih: the smallest repetitive component of Girih is called Vagirih that is drawn in a specific way in a special framework. It is not applied solely in implementing a Girih, but it is repeated in various directions and then Girih appears.

Girih Unit (Girih Background): it is part of Girih that is obtained from Vagirih repetition; and all of the Girih's features are visible in it. Girih unit can be used both in implementing Girih lonely and in expanding it in a large framework.

Girih device: it refers to any unit of geometrical pattern in a background (Girih unit). Therefore, the unit of working in Giril tile is called "Girih device".

20. Refers to the research hypothesis

21. Only in some Girihs known as "Dast-Gardan" Girih's form may be changed to conform to background.

22. Making a relationship between spiritual and material world is one of the aspects of tower tomb's architecture. Therefore, tombs and shrines and their components can contain symbolic and figurative concepts. The square form of religious buildings signifies certainty and invariability of law; the globular form of them signifies the sky and its limitless concept (Burckhardt, 1990, p. 18).

23. Each foot is about 30.48 centimeters.

24. Hillenbrand states that Seljuq tombs actuate the questions about their practicality. Some of them are located on main roads on the borders of deserts (Khosrogerd pylon), and this issue upholds the idea that they were make as landmarks.

25. These building is named "sepulchral towers" in most of books and articles, but it is incorrect as a building cannot be a modified by a tomb. But tower, that is a high-rise structure, can modify a building; therefore, it is better to name them as "tower tombs" (Ranjbar, Rafeei Sereshki & Rafiezade, 2003: 33).

26. Refer to postscript 16

27. Boolat Huf

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