

Decoding geometry, proportions and its relationship with aesthetics in traditional Iranian architecture

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Abstract

Certain proportions can be observed in creation and design of nature various forms. These proportions are geometrical relationships that are immaterial in origin and follow the spiritual and supernatural principles of their subject sacredness and have symbolic language and spiritual characteristics. Geometry was inseparable from other four Pythagorean sciences in traditional world, including geometric relationships, arithmetic (number), music and astronomy. We always need geometry knowledge in order to construct a building from first steps to final steps. Using proportions is particularly important because of creating visual aesthetic in visual and architectural arts, and almost all artworks are based on some form of proportion. This research tries to decode the work and find the aim and true purpose of its creator in responding the hypothesis that architect knowledge of geometry and his creative use facilitates the conversion of concept into space and form in designing process and minimizes concept erosion of process through studying architecture, geometry and existing proportions. The results obtained from library and field studies by descriptive-analytical method show that different proportions have been used in designing plans, sections and architectural patterns of Iranian traditional architecture.

Keywords: Geometry, Proportions, Iranian Architecture, Aesthetics

INTRODUCTION

Iranian architecture emphasizes beauty. Geometry is a powerful tool in hands of Iranian engineer in order to measure the proportions of sky and create balance, harmony, beauty and order on earth. Geometry is a good tool for architecture in order to apply fine-tuning and make informed relationships among components of a building, while being complex, enabling the integration of building as a creative and purposeful combination. The most excellent use of geometry can be seen in Iranian architecture of Islamic period. The fundamental purpose of all theories about fitness in work of art is to create a sense of order and organization among parts of a visual blend or visual composition. At first glance, the fit may not be visible to viewer, but emerged visual organization in a series of continuous experiences, can create a sense of beauty. The nature foundation and things in it are based on special proportions and human beings have long sought to discover these proportions in order to respond their curiosity and use these proportions in their creations.

On the other hand, geometry is a good tool for fine-tuning architecture and making meaningful relationships between building components, while being complex, to enable space integration as a creative and purposeful combination. The architect's awareness of geometry and its creative use facilitates the conversion of concept into space and form in design process and minimizes concept erosion in this process. The process result is a kind of architecture that is understandable in terms of order and proportion, far from

tastes. Architectural design is expressed in geometry form. Analyzing geometric relationships of valuable buildings reveals the architect's thinking way and decisions regarding problem and finding appropriate solution to it as well as reveals the ability of geometric thinking in fine-tuning architectural design process. In addition, the proportions use is particularly important due to visual aesthetic of visual and architectural arts, and almost all artworks are based on proportion. Geometry and proportions are integral part of architecture because architectural works are based on construction and it requires precise geometry and order. Generally, geometry is present in design and construction of mosques, schools and other magnificent works of Iranian architecture. The geometrical construction of monuments in Islamic era is the manifestation of Islamic wisdom in Iranian monuments body ^[1].

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How to cite this article: Mahmoudi, Sh., Rezvani, A., Hosseini Vahdat, S. A. Decoding geometry, proportions and its relationship with aesthetics in traditional Iranian architecture. Arch Pharma Pract 2020;11(S4):82-90.

One must take into account social and cultural role of building in addition to its formal aspects in order to identify the identity of an architectural work. Islamic symbols of a city become identifiable when they are connected to environmental performance system and affect the social and cultural interaction of people ^[2]. Islamic identity of a neighborhood is recognizable when the mosque is in its spatial focus in order to organize the form and type of interaction between citizens ^[3]. The geometric construction of monuments in Islamic era is the Islamic wisdom manifestation in ancestry of Iranian monuments ^[1]. Considering the theoretical and practical roots of these buildings construction is very important in the field of architectural criticism ^[4]. Therefore, theoretical roots along with geometrical characteristics must be taken into account in analyzing this group of architectural works ^[5]. From technical point of view on Iranian architecture, one can see the interaction between climate, geometry, engineering knowledge and artistic beauties ^[6]. The present study aimed primarily to examine the concepts, perspectives, and variety of geometric applications in past architecture in order to gain insights on quality and how the geometry is expressed and decoded in traditional Iranian architecture. The study examines how geometry has been used in traditional Iranian architecture? Thus, the main question of this research relates to understand the geometric principles of traditional architecture and its application quality in architecture. The main question of this research can be stated as follows: What are the geometric proportions and principles of traditional architecture? How are these principles manifested in aesthetics of Iranian architecture?

Literature review

The results of Hassan Balkhari's research in a book entitled "Philosophy, Geometry and Architecture" deals with the relationship between philosophy and architecture and the precise relation between thought and practice in Islamic thought using geometric and numerical examples by accurate illustration of relation between right and people in Islamic wisdom and the concept impact on Islamic architecture; other sections focuses both on explaining the spiritual traditions of architects and builders as well as spiritual perfection of city ^[7]. "Mojtaba Ansari and Ahad nejad Ebrahimi " in an article entitled "Proportional Geometry in Qyyunlu Turkman Architecture, Göy məscid Mosque (Turquoise of Islamic World)" concluded that proportions have been taken into account in building ornamentation in addition to its geometric structure through studying the geometry and proportions of buildings, decorations and shapes, materials and patterns on which motifs and Islamic and geometric shapes are aligned ^[8]. "Abdul Hamid Noqre Kar" in a study entitled "An Introduction to Islamic Architecture Identity in Architecture and Urban Development" examined geometry and proportions of Western and Iranian architecture with pre-Islamic and post-Islamic architecture and then studied its application in architecture and nature ^[9]. "Ali Dehar and Reza Alipour" in an article entitled "Geometric Analysis of Sheikh Lotfollah Isfahan Mosque Architecture to determine the geometric relationship of prayer room and building front

entrance" indicated that the dimensions of prayer room are proportional to front entrance dimensions and location of this Space is interconnected with geometrical positioning ^[10]. "Mojtaba Ansari et al", in an article entitled "An Investigation on Historical Progress of Proportions Adjustment Systems in Architecture with emphasis on functional and aesthetic considerations", stated that proportions of architectural works have been made before third century unconsciously and were based on human aesthetics but nowadays, proportions are used in order to induce beauty in viewer, but logical, numerical and geometric proportions are not used ^[11]. "Mehrdad Hejazi" in his article entitled, "Sacred Geometry in Iranian Nature and Architecture", studied on golden and delicate proportions that helped geometrically building beauty as well as using nature proportions in traditional Iranian architecture ^[12]. "Mojtaba Pour Ahmadi", in an article entitled "Geometry in Dome of Sheikh Zahed Gilani's Tomb: A pattern for dome design on South Coast of Caspian Sea", explored dome hidden geometry among its effective factors in order to understand dome formation by designer. In this paper, geometric analysis showed that there are special geometrical relationships in dome design, so the designer would have used such geometrical drawings in dome design, and part of work logic becomes clear ^[13]. "Mohammad Reza Bamyani et al", in an article entitled "Geometry and Properties Application in Architecture", provided aesthetically sound solutions through examining the concept of geometry and proportions with different perspectives as well as various historical periods and examples ^[14]. "Mahsa Kharazmi and Reza Afhami", in their article entitled "Applied Geometry in Decorating Iranian Architecture before Islam", examined three historical periods of the Achaemenid, Parthian, and Sassanid and concluded that applied geometry of Achaemenid architecture become more sophisticated geometric motifs through repeating the natural and abstract themes of Parthian art influenced by Greek art and had significant progress in Sassanid period in terms of increased complexity and new divisions ^[15].

METHODS

In line with research hypothesis, the present study method is analytic-descriptive. The research is based on library method, written documentation and field studies. For this purpose, library and descriptive study methods were used in theoretical foundations of research section that is related to geometry, proportions and Iranian architecture aesthetics, and then hypothesis was proven by analytical method in examining the information obtained from case samples.

Geometry and proportion definition

Conceptually, geometry means size and shape. Geometry is a mathematical science where study of space, shapes and objects is conceivable. This knowledge, along with arithmetic, is one of the two ancient branches of mathematics. The geometry science, like all other sciences, is derived from observation and experience and has related seriously to human economic needs. Also, proportion is a mathematical concept that implies a proper relationship between

components or whole work; all works of art are based on some form of proportion. Therefore, proportion is one of the basic principles of an artwork that expresses the harmonious relationship between its components ^[14].

Beauty and aesthetic in architecture

Any prominent and lasting work of art and architecture history have not gained a dignified status without meaningful identity. The interaction between architecture and beauty as art and man-made category has complexities for evaluation. Architecture as a four-dimensional phenomenon and a comprehensive artistic concept encompasses all human behaviors and affairs, and in a simple sense, it is life itself. The multifaceted nature of architecture designs various aspects of human life. Although material and spiritual needs are inseparable due to their composition, they correlate between motivations and beliefs based on architecture type and specific spatial and temporal situations. Human has concerned with spiritual needs and aesthetics sense since

architecture inception. The earliest instances of settlement indicate the establishment of such relationship. In other words, nature has been present in various cultures and related to aesthetics and architectural space. The sense of being in architectural space is directly related to human being in general and its users in particular. Just as beauty is not a quantitative and absolute concept, the quality of spaces cannot be measured ^[16].

The geometry place in architecture

Discuss on fundamentals of geometry application in architecture is time consuming, but a summary of these basics help to understand geometry place in architecture. This section of article reviews the views of Muslim philosophers and scientists on geometry. But, we will point to what makes geometry and order valuable among Muslims. "The totality of universe is understood by geometry, numbers and alphabet in Islamic art" ^[17].

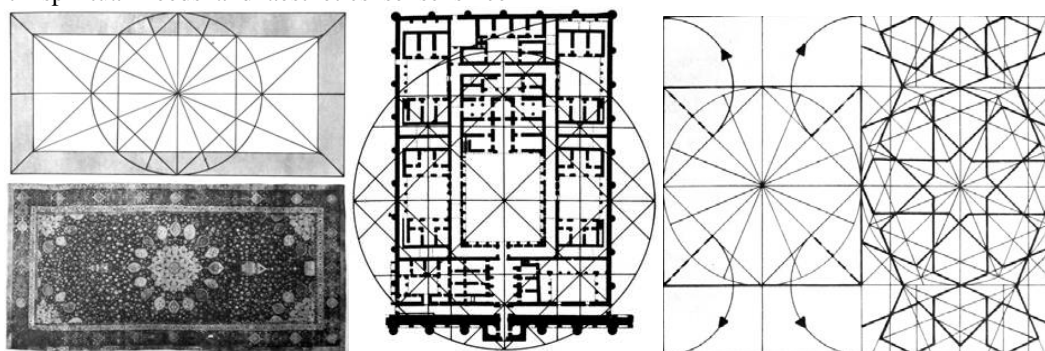


Figure 1: The geometry use in various branches of Islamic art has a special place, especially architecture and related arts. Examples of geometry use in Islamic artwork; Right: Geometric analysis of Sheikh Safi al-Din Ardebili's tomb carpet based on division eight, middle: Geometric analysis of Moshatta palace in Syria based on square and rectangle; eight: Geometric analysis of Chinese knot based on eight divisions (Reference: Al-Saeed: 1984: 60, 140, 160).

Historical course of geometry in Iran

Iran's past architecture has always been based on using rich and accurate geometry and drawing techniques. Knowing the mathematical and drawing rules and applying specific types of rules is task of architect; on this basis, architects differ and compete with each other.

Therefore, geometry is important in Iranian architecture and it is important to understand how indexes of contemporary

and past architecture work together. Recognize and introduce the effects and remnants of past civilizations and cultures, along with apparent economic benefits, includes national aspects; their simplified equation, where knowledge and techniques includes only protection and preservation, become complex equation and their recognition goes down to the most private personal and social life and causes social and political tensions.

Geometry classification in Iran

Before Islam

The geometric science application in this period included: Measuring geographical coordinates, determining seasons, mapping areas, astronomy and more

After Islam

-Applied geometry: geometry that is used in various jobs: architecture, casting, etc.
-Theoretical geometry: geometry that is related to principles, foundations, basic, general and theoretical discussions

-Applied geometry

The geometric science application in this period included: Establish Baghdad and Jundi Shapur schools, examine geometry with numerical calculations, translate and compile books on geometry and algebra, integrate geometry and numbers for the first time by Khayyam

-Theoretical geometry

Diagram 1: Geometry classification in Iran (reference: authors)

Geometry of Iranian Traditional Architecture

Iranian architecture emphasized on beauty and geometry science is a powerful tool that enables Iranian architect to measure spatial fit and create balance, order and beauty on earth. As architecture aimed to capture soul and intellect, geometry became a tool for Iranian architects in order to develop forms of plants and animals that were sacred in

nature. All sizes of architectural monument are interdependent in their perfection (height, length and width) and their constituents (including surface geometric patterns) and have never been separated from geometry. In this way, the geometry art is a key to establish a connection between building and ideas that builder has in his mind ^[15]. In other words, geometry is part of beauty concept manifestation in Iranian architecture.

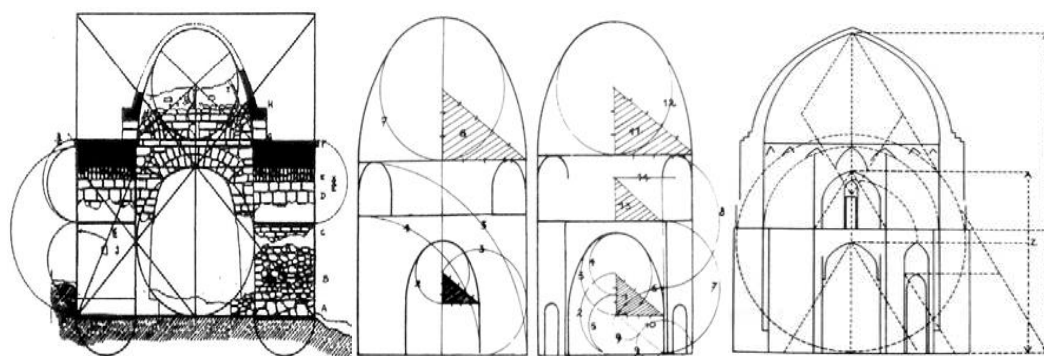


Figure 2 - Right: Geometric Analysis of Niasser Foursquare from Hardy ^[18]. Middle and Left: Geometric Analysis of Taj Al-Molk Dome and Isfahan Jame Mosque ^[19]

• Plan geometric order

Specific geometric order integrates the components and whole building. Considering logical geometry in building map, the overall volume of building can be better understood. This geometry is not always a tangible and visible network, but a system whose task is to regulate and control different spaces of single device ^[20].

• Symmetry

Symmetry is top of solid thinking that moves forward with clear instructions and regular rhythm. One can point to Rostam role and Zoroastrian Kaaba structure among many examples that are symmetrically constructed along their long axis (Figure 3).

• Rectangular geometric order

Rectangle is one of geometric polygons that are used in architecture; for example, Cyrus' private palace (Figure 4) or courtyard of many buildings.

• Square geometric order

It can be said that square is a subset of rectangles and are used in many buildings; for example, four-floor Shirin palace which is 25 × 25 square in size.

• The circle geometric order

Traditional architecture can be seen as a fundamental extension of circle-to-square conversion by triangles. Square is the most embodied form of creation that represents quantity at earth level, while represents quality at sky; they are merged through a triangle that embodies both aspects ^[21]. The transitional but primitive forms of Sassanid Foursquare - Niasser Fire Temple (Figure 5) can be regarded as a preliminary explanation of this issue.

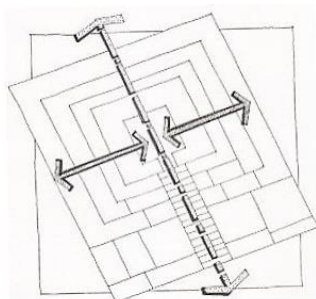


Figure 3. Symmetry
(Reference: Authors)

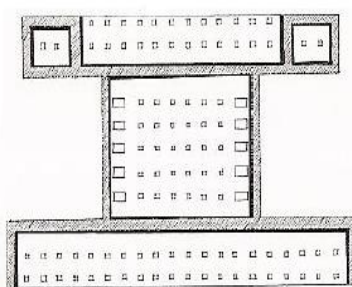


Figure 4. Rectangular Geometric
Order (Reference: Authors)

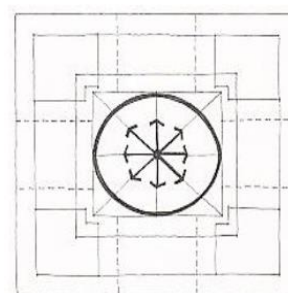
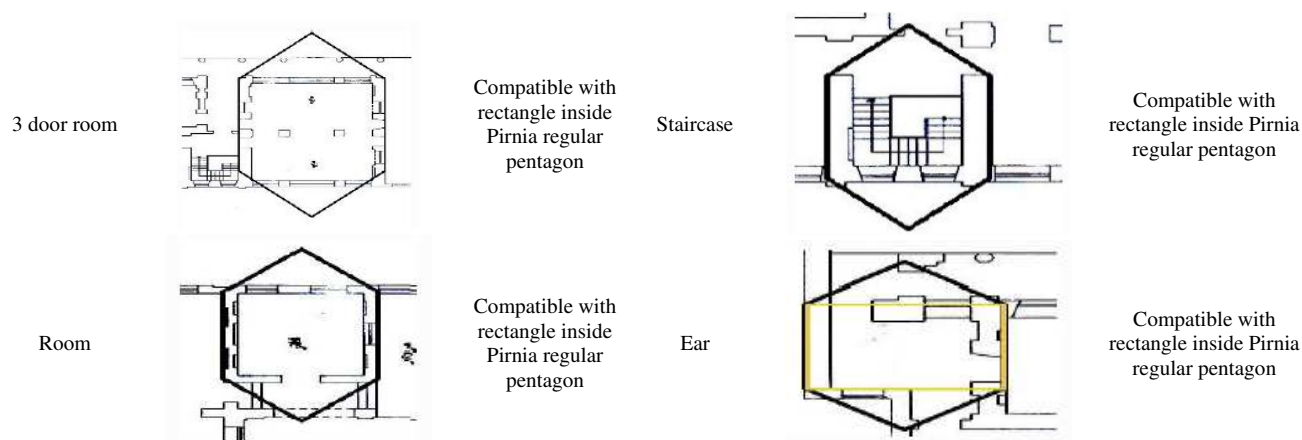


Figure 5. Geometric Order of
Circle (Reference: Authors)

Table 1- Spatial analysis and its relation to geometry and proportions from Professor Pirnia point of view

Space name	Compare plan with Pirnia golden proportions	Explanations	Space name	Compare plan with Pirnia golden proportions	Explanations
3 ramped staircase		Compatible with rectangle inside Pirnia regular pentagon	3 door room		Not compatible with golden rectangular
Room		Compatible with rectangle inside Pirnia regular pentagon	Room		Compatible with rectangle inside Pirnia regular pentagon
Room		Compatible with rectangle inside Pirnia regular pentagon	Inside yard		Not compatible
Room		Compatible with rectangle inside Pirnia regular pentagon	Central yard		Compatible with rectangle inside Pirnia regular pentagon
Porch		Not compatible	Staircase		Compatible with rectangle inside Pirnia regular pentagon



(Source: Authors based on Pirnia's golden proportions)

All humans have generally an understanding of beauty, recognize the enjoyment of musical notes, and consider some fragrances as desirable. Also, they consider some images as ugly, some sounds as scratched, and some smells as bad. These capabilities are intrinsic in human and need no special training. In other words, there are adjustments in world that are not contractual and do not depend on time or place. Research and experiments by people such as Fischner, the German philosopher and psychologist (1876), Mitt Mar (1894), Lula (1908), Trendik (1917), and Huntley (1970) support this theory (Saleh Mojtahed, 1999 quoted by Tahebazz, 2004: 98) ^[22].

From a philosophical point of view, Plato, citing the world of forms existence and human two- sidedness (body and soul), believes that soul existed in human body before its incarnation and resided in universe. But, soul forgets those supreme examples when entered the body. A vague memory flashes in human soul, when he observes various facets of natural world (Gadder, 1996, quoted by Tahebazz, 2004: 103) ^[22]. He believes that the closer the shape, sound, or meaning in real world, the easier it is to remember. The Plato's world of forms is comparable to spiritual world of Islamic thought. Spiritual universe and world of forms has a form, but there is no correspondence in literal meaning. Iranian scholars like Molla Sadra have elaborated on this world and have written many separate epistles about it, such as Qutb al-Din Lahiji treatise, Baha'uddin Lahiji treatise, and Molla Halahadi Sabzevari treatise ^[23].

This is a world that Muslim artist reminds in architecture, music, miniature, etc. A world in which human nature is familiar with its shapes and sounds, and artist immortalizes these shapes and sounds in his work. For example, the space of Iranian miniature is actually a diagram of this celestial space, and its shapes and colors manifest world of forms' shapes and colors. The colors of Iranian miniature, especially gold, blue, cyan and turquoise ones are not simply derived from artist's illusion, but they are the results of reality-based vision and intuition that exists only with a certain intelligence and awareness in artist. Since the observation of sensible

world requires body eyes, world of forms vision requires the opening of heart eyes and attaining intuition status ^[23].

Symbolic meanings of geometric shapes

Pythagoras and his followers believed in a relationship between numbers, shapes, and music. Also, Islamic philosophers such as Akhavan al-Safa believed in emergence of a world based on numbers. According to them, number is essence basis of universe, and therefore, a number must be considered as pure quantity. In this thinking, number is not the value that is used to measure physical quantities. Two is not a digit after one and does not come from double ones sum, but one converts to two through dividing itself into two. In this thinking, numbers start from one and each number has its place. The number one can denote quantity, but in other sense, it can represent the principle of absolute unity. Thus, it is presented as a symbol of God. It also represents point in terms of form, or in another sense, it can represent the complete circle. Number two represents symbolically the principle of duality and force of plurality. At the same time, in its formal sense, it represents a line bounded by two points. Number three is a quantity. As a matter of principle, it offers Trinity. Its formal meaning is a triangle made of three points. Number three provides a qualitative change in abstract elements of point and line and leads to a measurable and tangible quality called surface. The triangle acts as mother form ^[24].

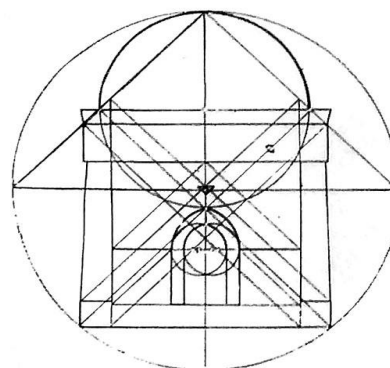


Figure 6. Geometric analysis of Amir Ismail Samani tomb ^[19]

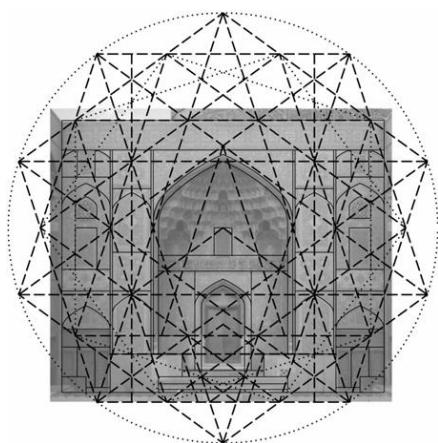


Figure 7. Geometric analysis of Sheikh Lotfollah Mosque facade by Haji Qasemi, 1996: 20 (Source: Redrawing by authors)

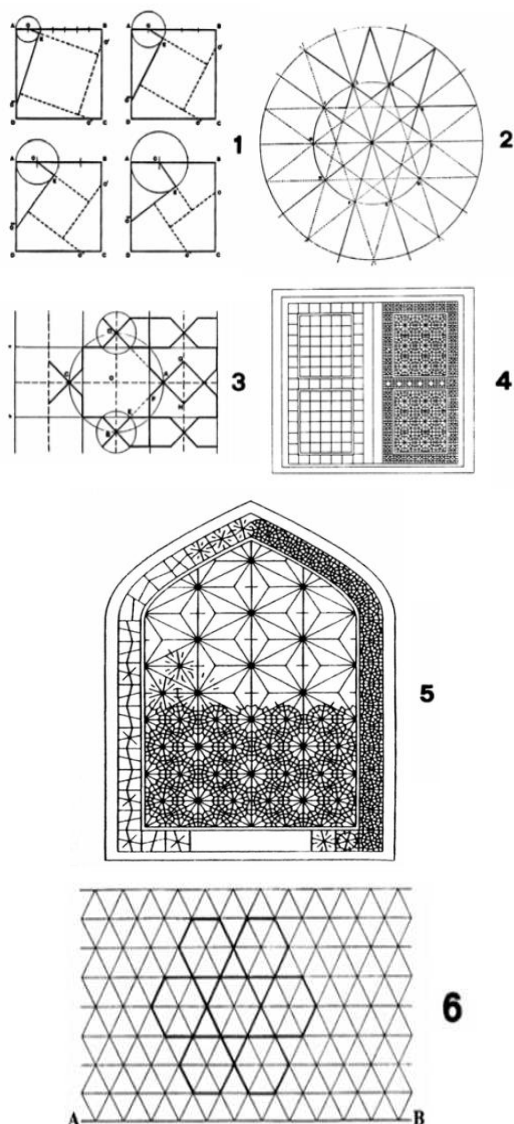


Figure 8- Professor Donato's study on examples of Chinese knots and hexagon-based tiling ^[25]

Ultimately, number four represents natural world and offers a tendency towards matter. Number four indicates four-sidedness of some phenomena such as main geographical directions and seasons. It is shown by square forms ^[24]. Number five is known as blossoming or essence of life. Five plays a vital role in nature. For example, chrysanthemums and roses have five petals, like all plants having edible fruits. Therefore, number five reflects signs of complete diet for humans. The pentagon is symbol of life, especially human life ^[24].

Number six in Islamic culture is number of days when whole universe was created (Yunus: 3 and Hood: 7). In addition, it is a symbol of natural world. Suhrawardi refers to this number as a prison with six directions in his truth of al-Ashq treatise. He has referred to six ropes as six directions in the same treatise, (Suhrawardi, 1997: 158, quoting Naqizadeh, 2004: 10) ^[26]. Professor Donato considers Islamic architecture and urban planning with precise geometrical foundations despite its organic appearance. He explores the Islamic geometric motifs and achieves the hexagons of Chinese knot from square as a symbol of world and then extends it in urban fabric plan ^[25].

And finally, the most prominent symbol of number eight in Islamic thought is carriers of divine throne. The carriers of divine throne are eight angels at resurrection (Saduq, 1951: 40; quoted by Naqizadeh, 2004: 11) ^[26]. Also, number eight is number of Eden doors ^[26]. Sun Palace plan appears at first glance as an irregular octagon shape. Shapes come from numbers. Similarly, the steps and harmonics of music are arranged in numbers. Ackerman regards architecture as embodied music due to common numerical roots ^[27].

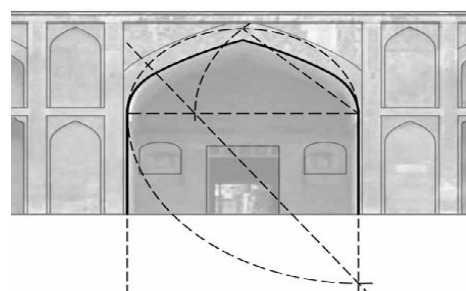


Figure 9. 5&7 arc drawing on south porch of Sun Palace

A famous example of geometry use in architectural drawings

Sacred geometry of Iranian architecture and patterns

In traditional architecture, geometric patterns are like plural forms in unity. Repetitive patterns symbolize timelessness idea. Beauty and harmony of geometric patterns reflect a higher and deeper geometric order, the cosmic laws. The spiritual man discovers geometric patterns as a means of understanding and reaching God.

Mathematics of two-dimensional geometric patterns

Geometric patterns of Iranian architecture are used as spatial concepts in order to fill surfaces; patterns grow together in order to cover one surface. If a flat surface is covered with

regular shapes or polygons, so that there is no space between intersection points of vertices, what are those polygons? Mathematically, it can be shown that there are only three regular polygons, known as planar regular planes which fill exactly one surface such that sum of vertices is 360 degrees: triangle, square, and hexagon (Figure 10).

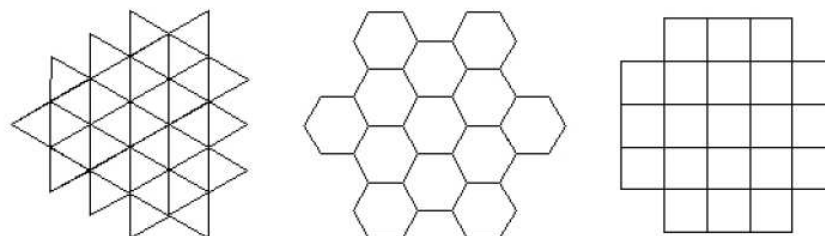


Figure 10- Three regular patterns that fill exactly one two-dimensional surface ^[12]

The composition of these three regular polygons consist of eight semi-regular patterns in which vertices are the same in all cases (Figure 11) as well as fourteen regular quadrilateral patterns in which vertices change. These are main space-filling patterns that are called mosaics, grids, or grid patterns ^[28].

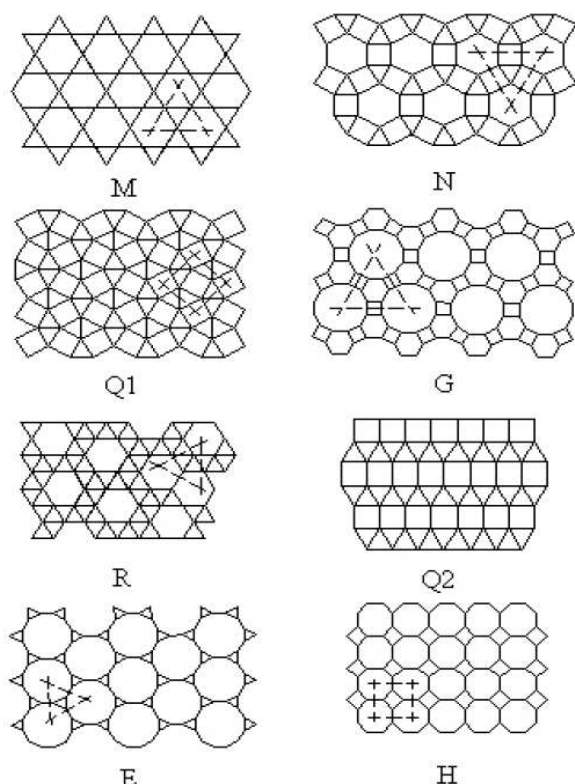
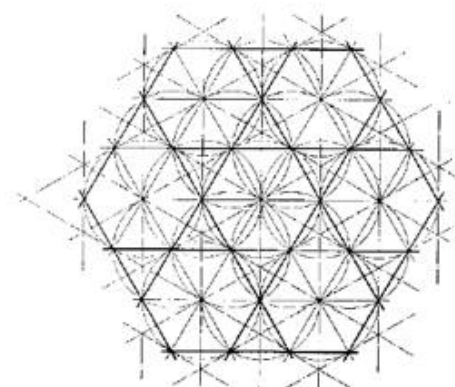


Figure 11. Eight semi-regular patterns, adapted from Cricello, 1976

Geometric patterns have been widely used in Iranian architecture. Figure 12 (a) shows the semi-regular pattern of combined triangles and hexagons. Figure 12 (b) shows a similar pattern of tile work in Yazd Mosque.



(a)



(b)

Figure 12. Pattern of semi-regular tile grid, Yazd Jame Mosque ^[12]

CONCLUSION

There is an inherent characteristic in both scientific and artistic dimensions, upon which architectural style is developed. The intrinsic value is a meaningful mirror that reflects divine beauty in material body and is reflected as a

harmonious interconnection between phenomena rational relationships through introduced geometric patterns which are based on proportions and symmetries of Iranian architecture. So geometry has been used as a sacred tool, a powerful tool for right proportions in architecture in order to create congruence between matters and meaning; these proportions are found in many forms of natural life and are used elaborately by architect of that era in order to create an architectural style that demonstrates correct design and engineering techniques.

So that, phenomenon gets beauty and perception creates ultimate beauty in audience based on aesthetic approach. For this reason, the geometry determines order systematically in many of structures in order to show divine beauty influence on urban design. According to paper aim, namely, the study of geometry aesthetics role in Iranian traditional architecture, it can be concluded that numbers and shapes of geometric structure show spiritual attributes that relate to each other using principles of geometry and mathematics, where, geometry appears both quantitatively and qualitatively. The quantitative dimension regulates the architectural form and structure, and qualitative dimension establishes semantic ratios between architectural forms that represent meaning and order expression in universe and regulate manifestation cycle. Now, if ultimate aim of art and architecture is to create right context for growth and emergence of highest intellectual and rational talents of man, then one must consider the geometry and proportions that are one of architectural art tools in advancing architectural goals and influencing human perceptions. Since nature and creation are achievements of the best architect and creator, so inspiration of creation spatial and geometric structure and its verse and allegorical dimensions are the best source of inspiration for artists and architects.

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