Role of Geometry in Formation of Traditional Iranian Houses

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Abstract
Use of geometry in Iranian architecture and art has a long history. Geometry has been one of the most important design instruments, both in pre-Islamic and Islamic Iran, through which subjective and spiritual ideas have been materialized, and presented in form of architecture and art. Given abstract quality of geometry and Islamic view of architecture and art, role of geometry became much more important in Islamic period. Therefore, as an instrument, geometry has a very important and effective role in formation of Islamic Iranian geometry. Such effect manifests itself in plan, size and architectural decorations. Such role and effect is visible in residential architecture as well, and geometry has been used in all processes and steps of design and all details of building. This paper aims to study role of geometry in formation of traditional Iranian houses. For this purpose, analytic-descriptive method, library study (books, Persian and Latin papers, pictures and drawings), review of relevant literature, direct observation, and analysis of many instances of traditional houses, were used to study role of geometry in formation of traditional Iranian houses.

Keywords: Islamic Iranian architecture, geometry, residential architecture

Introduction
Historically, housing has been one of the primary human needs. It has always been tried to construct the house in the best way possible so that it would meet the material and immaterial requirements of the users. Based on their specific worldview, Iranian Muslim people also seek elements in their life environment that are rooted in their beliefs and values, and they become distressed when such elements are not present in their life environment. This becomes even more important when it comes to residential building because a large part of human life is spend at home, and home provides a secure privacy for Muslim people, which separates them from the distresses of the outdoor life, and provides them with a secure privacy, and naturally it can have the largest effect on human. One of the prominent elements in Iranian houses is geometry. However, traditional and contemporary Iranian architecture are significantly different in terms of their view and manner of using geometry. Traditional architecture, qualitative aspects of geometry are more important than its quantitative aspects while contemporary architecture uses geometry as an instrument that merely has quantitative properties. Such approach to geometry, which uses it as a design instrument in design process, causes the human residential space deviates from proper conditions.

Literature review
Given its importance, the issue of the role of geometry in Islamic Iranian architecture has received significant attention from different scholars. Given the magnitude of the effect of each element, different researchers have studied it from their specific perspective. Many of them have focused on physic of building and role of geometry in it, another group has discussed the role of geometry in decorations of building. There are only brief references to role of geometry in formation of Iranian residential architecture in literature, and it has not been discussed as the subject of a full paper. This paper tries to do this task.
**Geometry and Islamic Iranian Architecture**

According to categorization of Islamic sciences, geometry falls within category of mathematics, and it is defined as science of knowing values and proportions and ratios (Hosseini, 2011: 9). This branch of science has a major role in formation of Islamic Iranian architecture, including drawing, size and different decorative elements (Daneshdoost, 1995: 20). Since language of Islamic Iranian architecture is originated in abstraction, geometrically in general, and geometrical proportions and ratios in particular, are very important in Islamic design process. Such abstraction is visible in principal forms, calligraphy, decoration, etc. Therefore, it is concluded that principles of Islamic design are rooted in geometry, or in other words, geometry has an essential role in Islamic architectural design (Dabbour, 2012: 381). Also, geometry is good instrument to order and organize architecture and create knowingly established relations between the elements of building, so that in spite of the fact that different elements are mixed in architecture, a creative and purposeful composition with spatial integrity and consistent is ensured (Dahar&Alipour, 2013, 34). The best application of geometry is found in Islamic Iranian architecture. Muslim Iranian architect ensures beauty and utility of building through proper and innovative use of this instrument, and realizes the concept of “multiplicity in unity in an innovative manner, which is nothing but the main teaching of Islam, that is, unity is harmony of elements, proportionality, and order of the whole building. For traditional architect, geometrical patterns are regarded as the forms of multiplicity in unity. The beauty and harmony in geometrical patterns reflect a higher and deeper geometrical order, that is, the cosmic laws. Spiritual human seeks to discover geometrical patterns as a means to know and reach the God (ibid).

**Geometry in Space of Residential Architecture**

**Diagram 1: Geometry in architectural space**
(Source: authors)

**Open space**

The courtyard is one of the most important spaces in Iranian house, to the extent that it is considered to be the heart of the house, and all spaces and activities occur around it. In traditional Iranian architecture, it has always been attempted to make sure that the courtyard has a rectangular shape, and in case the land on which the promises were constructed was not rectangular, it was tried to turn those parts of the land disturbing the rectangular shape of the court yard into private spaces so that the geometrical shape of the court yard would not be disturbed. In many Iranian houses, such rectangular shape follows the Iranian golden ratio. In public space of residential architecture, inanimate, plant and animal nature, which shows multiplicity of various shapes, colors, textures and scents, are designed in an orderly and symmetrical geometry (Shahidi and Bemanian, 2009: 50).
This is clearly seen in arrangement of plants in the courtyards of traditional houses. In addition to order and symmetry, gardens have special geometrical shapes, they are mostly rectangular. However, in some buildings, gardens are in other geometrical shapes as well; for example, in Tabatabais House, Kashan, there are hexagonal and octagonal gardens, which are symmetrically placed along the pool on two sides of the pool. In addition to gardens, sunken gardens also follow a particular geometrical shape in many cases. Sunken garden in Taraghi House, Yazd, is a good example.

The pool reflects the light. Islamic philosophy, world of idea is an intermediate world between two worlds, the metaphysical world and the physical world. All archetypes are in this world. Given the concept of ideas and world of ideas, it is possible to bridge physical and metaphysical worlds by thoughts, give material forms to heavenly attributes by the aid of property of reflection of architectural space, and so stress on concept of extension and world of ideas (Bemanian and Azimi, 2011: 46). The important point here is that in the viewpoint of many scholars and philosophers, geometry is among the most important instruments for manifestation of world of ideas in the physical world. Then, when geometry is accompanied with reflection, it doubly strengthens meanings presented. Then, by combining two elements of reflection and geometrical shape of the pool, which appears in Iranian hexagonal, twelve-sided and rectangular shape with golden ratio, etc. (Pirnia, 2000: 163) and through the position of these two, one unified element is formed, which serves expression of unity in architecture.
This is because in traditional architecture, the court yard is the heart and center of the house, and presence of the court yard in Iranian houses is the symbol of introversion. The pool itself and its location also stress such centrality and Unitarianism (Toofan, 2006: 76).

**Geometry in semi-open spaces of Iran Houses**

Ivan is among the most important spaces in Iranian architectures, and is present in most traditional houses. It has diversified forms, dimensions, and locations, and has many functions (Mahmoodi, 2012: 55). Most Ivans, as the semi-open space that has view over public space of the house are U-shaped, and are covered with arch. Inside this space, blind arcade and shelves are embedded, which naturally follow the rules of geometry. One good example of such Ivan’s is Mortaz House, Yazd. Ivan of traditional houses, especially those in central cities of Iran, have beautiful geometrical and non-geometrical decorations in form of stuccos on the walls, because ivan is one of the main residential spaces in summers. Ivans of traditional houses didn’t have railing, however, in cases where they had railings, the railings were made of wood, and had geometrical decorations called gereh (geometrical knot), and contributed to richness of semi-open space. An example of such railings is seen in Borujerdis House. In case there were columns in front of the Ivan, there were odd numbers of such columns so that the view of ivan was divided into the odd number of spaces between the columns.

![Figure 6: Ivan, Mortaz House (Hajighasemi, 2004, 181)](image1.jpg)  ![Figure 7: Ivan, Borujerdis House (Source: authors)](image2.jpg)  ![Figure 8: Railings of Ivan, Borujerdis House (Source: authors)](image3.jpg)

**Geometry and Proportions and Ratios in indoors**

Geometry and proportions and ratios in indoors of architecture have many applications due to diversity of spaces, and effect of geometry on plan, section and other elements of architecture is clearly seen in traditional Iranian houses.

**Geometry and Decoration:** Tendency to use decoration is one of the human inborn needs; it is a requirement of human social life, which is embedded by the God in human nature (Ansari, 2002: 65). However, in Islam, due to its special ideological bases, illustration of animate creatures is forbidden. For this reason, Muslim artists turned to abstraction. The best instrument to create abstract forms and shapes is geometry. BernardO'Kane divided architecture-related decorations into four categories, one of which is geometrical decorations. However, importance of geometry is quite clear not only in geometrical decorations but also in other types of decoration (Mehdizadeh et al., 2012: 18).

**Geometry and gereh (geometrical knots):** One of the decorations in which geometry is best used is gereh. Gereh is a set of different geometrical shapes, which are juxtaposed harmonically and in a special order in certain contexts. They are complex textures, all of which have a rhythmic and homogenous composition, and can be extended in all directions, without their rhythmic, orderly and homogenous composition being changed.
Presence of gereh in buildings highlights the geometrical order of the buildings, and turns the building into an embodiment of order and geometry. Gereh is absolute order, balance and harmony (Bayanasl et al., 2013: 85). In Iranian residential architecture, gereh tiles have been used in many instances. One good such instance is use of gereh in sash windows and other types of door and window used in traditional houses.

Geometry and karbandy (brickwork): Another type of decoration that is based on rules of geometry is karbandy. It is a type of coating comprising beam and arches with specified arch that intersect each other according to geometrical rules (Mohamadian Mansour and Faramarzi, 2012, 98). A very good example of application of karbandy in residential architecture can be seen in coating of the ceilings of vestibules.
Art of inscription has a long history in Iranian architecture. This art continued into Islamic period. At least three types of calligraphy are seen in Islamic buildings. The important point here is that much calligraphy used in Islamic Iranian architecture are based on geometrical rules (ShekariNayeri, 2006: 11). Masonry calligraphy is a type of calligraphy that is based on geometrical rules. Masonry calligraphy is angular Kufic calligraphy, which is performed by drawing geometrical shapes such as square, diamond, rectangle, and parallel and intersecting lines (Mehrpuy, 1997: 567). In Iranian residential architecture, line has been used in façades and as a decorate element.

Geometry and its proportions and ratios in plan
Symmetry in Plan: In many traditional Iranian houses, elements of building are symmetric. One of such elements is plan, and given spatial linkages, symmetry is found in many buildings. Such symmetry is sometimes longitudinal, sometimes transverse and sometime a combination of these two.

Use of module in design of plan: In Iranian architecture, dimensions have an important role. Architects have provided beautiful designs by accurate calculation, and simple rendering, using module as the instrument as the measure and benchmark. Thus, module is an important rule of Iranian architecture, which is used by the architect to link the elements of building. In Iranian architecture, two types of module have been used (Bemanian, 2002: 1). Small module with length of 14 knots (93 cm), and large module with length of 18 knots (120 cm) (Pirmia, 2009: 158). As a result of using ordered and fine geometrical networks, despite diversity of proportions and ratios, rhythms and shapes, an inherent and invisible heavenly harmony is established between all of different geometrical elements, like what is found in warp and weft of carpet (Noghrehkar, 2008: 608).

Use of proportions and ratios: Unique numerical ratios have been used in physic and space of building. The best known of such ratios in the world architecture is the golden ratio, which denoted by 1.618. In Iran, ratios of 1.414 and 1.73 are most commonly used ones, of which 1.73 was named as Iranian golden ratio by Master Pirmia. This ratio holds between length and widths of a
rectangle enclosed in a regular hexagon (ibid: 417). In traditional architecture, rooms are constructed according to the golden ratio. For example, ratio of the rooms that are lighted transversely is half the golden ratio (Pirnia, 2009: 162).

**Geometry and Façade**

Symmetry in Façade: The primary geometrical feature of façades in Iranian houses is symmetry. In addition to objective of facilitating design of structure, symmetry in internal façade has a religious objective, which is indication of unity and centrality of the God. Muslim architect has a centralist view. Unity is the essence of the being. This principle of Islamic architecture has always caused formation of shapes that have center or axis (Bemanian et al., 2011: 61).

Odd division in design of façade: In design and construction of façades, an odd number of columns, and windows is considered, that is, three, five or seven, so that the central space be empty, and human’s vision not be fixed and focused on masses of building, such as column, pier, walls, or windows’ profile. The point to note here is that such rhythm and constituents of façade are not fixed and repetitive, but they are completely different in different parts of façade in terms of width, height and shape, and ultimately, they integrate into the dominant central element of façade, which is often larger and more highlighted, and comprises the more principal part of façade, to form a consistent and harmonic whole (Noghrehkar, 2008: 604).

Geometry in design of façade’s arches and chefds: Arch can be defined as a curve that is part of a particular geometrical shape, for example, part of a circle, hyperbolic or curve; and chefds is a combination of a number of arches (Pirnia, 2000: 45). For example, the simplest form of arch is semicircle arch, which refers to as compass chefd. As seen from the definitions, design of all arches used in Iranian architecture is based on geometrical rules and derived from geometrical shapes.

**Figure 18: Symmetry in façade**
*(source: authors)*

**Figure 19: Geometrical arches**
*(Mehdizade, 2012, 41)*

Geometry in section: Use of module in communicative elements: as said above, module has been used in design of various elements of Iranian architecture. It should be noted that module has also been used in designs. It is clearly seen from study of dimensions of doors and communicative elements that such dimensions were chosen based on size of Iranian people, for example, height of doors was equal to height of an Iranian man of average height (Pirnia, 2009: 159).

**Conclusion**

As said earlier, literature on role of geometry in Islamic Iranian architecture has often studied the non-residential buildings. In the paper, for studying the role of geometry in residential spaces, first the role of geometry in open, semi-open and private spaced was studied. Then, the role of geometry in elements of architecture, which mostly included private spaces, that is, façade, plan, and decorations, were studied; next, providing different examples and pictures in this regard, it was shown that geometry played a very effective role in residential architecture in Iran, and has been used as a powerful instrument by Iranian architectures in order to render the concepts that are rooted in their beliefs.

Openly accessible at [http://www.european-science.com](http://www.european-science.com)
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