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Geometry in Iranian Traditional Architecture (Case: Residential Structures)

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Abstract: In nature one can see specific geometrical shapes. Architecture is closely tied with geometry, and it has created different places over thousands of years, Iranian architecture has always been in the favor of order and beauty and Iranians have always tried to consider proportions in shapes, sizes and orders. In the world of geometry, everything can come to existence, a house or even a city, and they can find their identity. In the universal and lawful world of geometry everything has its own sizes and qualities and this makes them unique.It is by means of geometry that every object finds its limits and size and get in touch with the environment and find its path towards the completion without any interruption. In this process, all universal particles find wholeness and all surrounding objects help identifying each other.

GEOMETRY IN IRANIAN ARCHITECTURE

Geometry has a fundamental role in designing Iranian buildings. From the outside, it is an art to create shapes and patterns and proportions which reminds us of the creations by God. Geometry is a key element to link between the building and the architect's intellect. From the inside, it is a science that helps to choose the proper size, length, width and height and to know the influence of materials on the construction. A geometric approach leads to a functional building. Elements that influence residential buildings are size of the area, foundation, geometry of the area and natural elements.

Geometric analysis of many historical buildings in Iran, and especially the golden proportion is widely used in Iranian architecture and this is the base of Iranian esthetics.

In many of Iranian buildings the plan and the perpendicular section are designed in a framework of squares and equilateral triangles the intersection of which defined the important stable points like width and height of the doors and width, length and height of the halls and the position of epigraphs and so they like. So every section was linked to another section according to a specific proportion. So, a building was a combination of proportionate parts that gave movement to the space and tranquility to the eye.

For instance, the golden proportion in geometric designing of the dome of Taj-ol-malek in Isfahan jame mosque is astonishing. The outer diameter is 11.7 meter. It is 20 meter high from the ground. The thickness of the dome decreases as it goes up.

Sheruder describes it beautifully "it is the most beautiful Iranian construction. It is astonishing in every aspect (geometric, aesthetic and mechanic)" He describes these qualities. He shows the golden proportion in this building. His geometric analysis shows that the architect has chosen a pentagon in the center of a big equilateral as a symbol of proportion. And the proportions are considered in every point of the construction, like in the point of the arch and sides and etc.

It is justified that the golden proportion is applicable in structures if the smaller part is up.

One can say that, the size of the golden rectangle was the touchstone (peymun) of the architect. We can describe this rectangle as a repetition of Dome to foundation and then towards the other parts, which is called the golden spiral.

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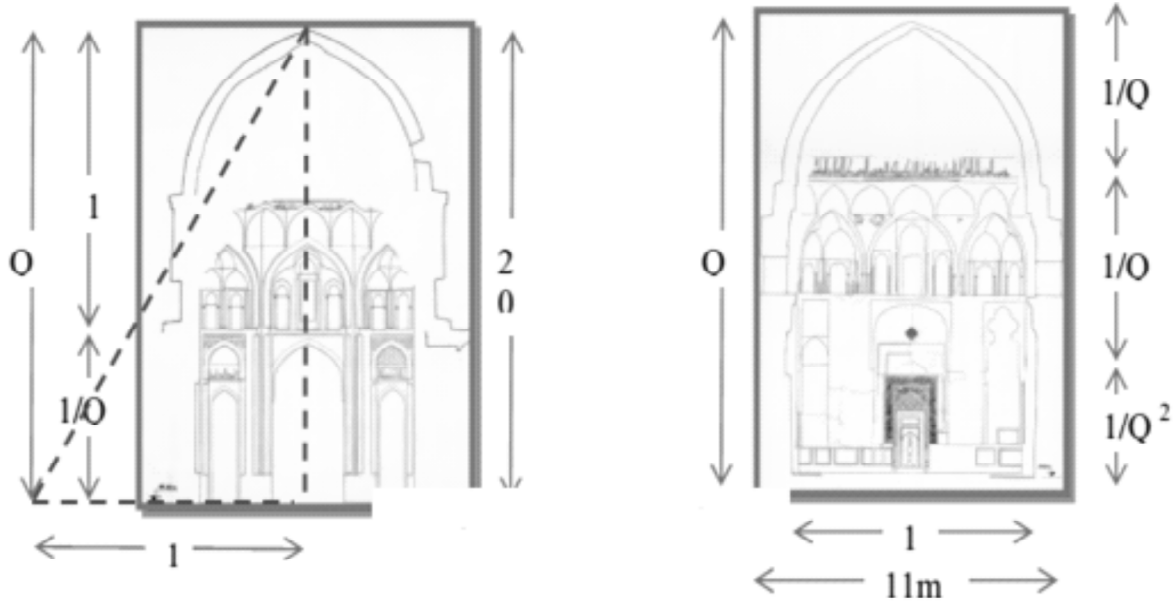

Figure 1: Taj-ol-malek Dome sections

In Iranian architecture, because the proportions were acquired using geometry, the designing was efficient.

The overall geometric pattern in residential building

In Iranian old architecture, a house was built according to special base and patterns. These patterns were followed in every type of houses; no matter of it belonged to a lord or a simple man. Of course, some further varieties are witnessed in the houses of the lords.

The oldest pattern in building houses is the char-chefte or char-saffe which is also called the four-house; because they have 4 rooms. Thos pattern consists of a central four-walled space covered with a dome and there are four rooms in the sides. There is a big opening towards the sky that is not covered for it gives light. Around which bricks are laid, and half of which is open. Four rooms have openings to the saffe's.

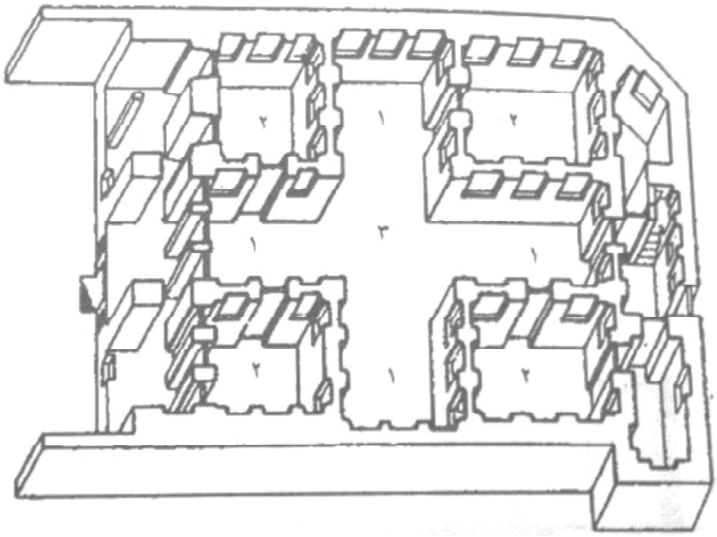

Figure 2: Miansara. Arabs' house

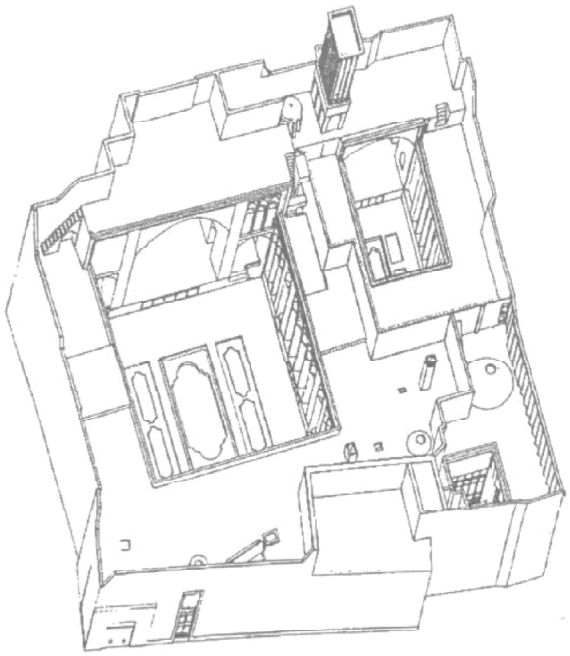

Figure 3: Char saffe

This pattern is very proportionate to Iranian Lifestyle; Because first, it is an introvert pattern and second, temperature changes are not severe. This provides a cool house in summer and a warm one in winter. And third, this method could be made with dome or wood.

In houses with myansara, every part of the house is built in one side of the myansara. Sometimes three or four sides are rooms. One side faces south-east and another faces south-west; so both are used in winter for heat of the sun.

The third faces North-east so it is practical in the time of hot weather, because it does not have light. And the fourth is covered, because its sun is irritating. This side is mostely used in springs or as storehouse.

These houses generally have two parts: outer and inner part. The inner is bigger and wider and was specially designed for personal life. It had many rooms and has special spaces for summer and winter.

These people really liked their guests but they did not want them to enter their personal territory so they devised big guest rooms in the outer space for parties and guests' rest.

Saffa (stone bench) means a place higher than the ground. There are many examples of saffa in Iranian architecture, alone or mixed with other elements.

Char-saffa (four stone benches) is an architectural and beautiful pattern, devised with symmetrical orders. Saffa has been used different architectural spaces such as a few residential buildings, caravanserais in the brink of Persian Gulf and some public baths and teahouses.

One pattern of Char safe, examples of which are present in Zavareh city consists of a central space, with a square or octagonal map and the four saffas are in a line. On the other hand in some other buildings like baths and springhouses we can see that the four stone benches on the sides are all higher than the central space. And the importance and centrality of this central space is emphasized using other architectural patterns.

ORDER AND SYMMETRY PATTERN

Symmetry exists in different levels in Iranian architecture. And these levels are not identical. There are different kinds of symmetry. On a higher level, different viewpoints and stands are not always symmetrical. Sometimes they appear in organic or complex shapes. There are fever symmetrical plans than symmetrical viewpoints. In a more holistic view, symmetry-making pivots are less in the bed because of limitations. The pattern for symmetry in different levels is like a tree, the trunk of which is the pivot of symmetry and the branches are the symmetrical elements.

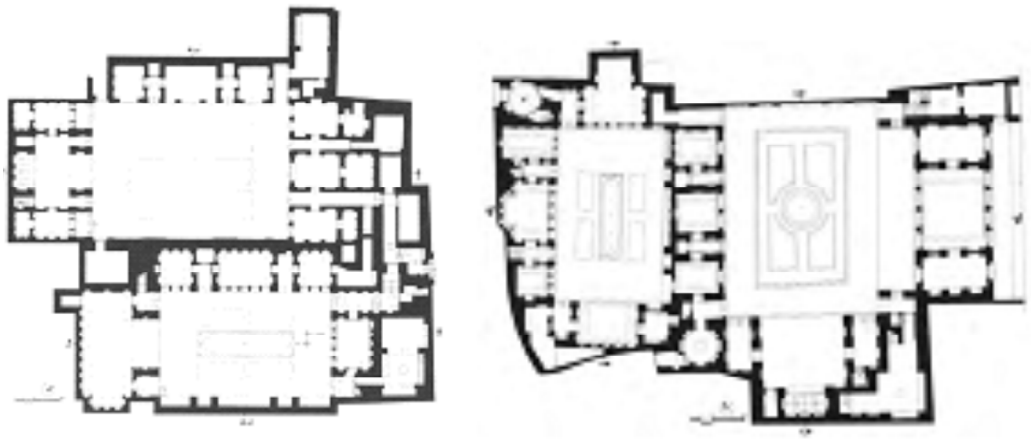

Figure 4: Different levels of symmetry in Iranian houses. Lack of symmetry in the whole plan and symmetry in the yard and its wings

In an overall view we can see that in residential buildings because of the bed of the plan and presence of many yards, it is not symmetrical. But yards are symmetrical and façades are individually symmetrical.

Fractal Order

In Iranian architecture, there are certain plans and there is always an internal complexity which comes from the subjective pattern and not physical complexity.

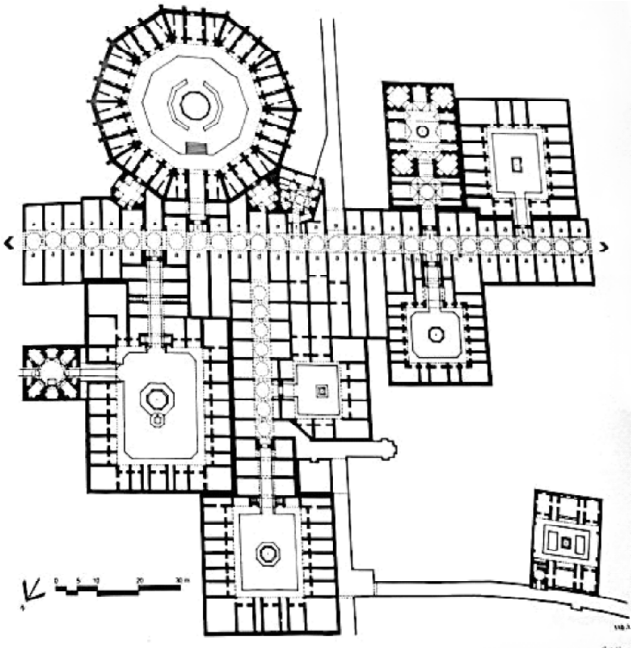

Figure 5: Using fractal geometry in a bazar. Similar squares in different sizes.

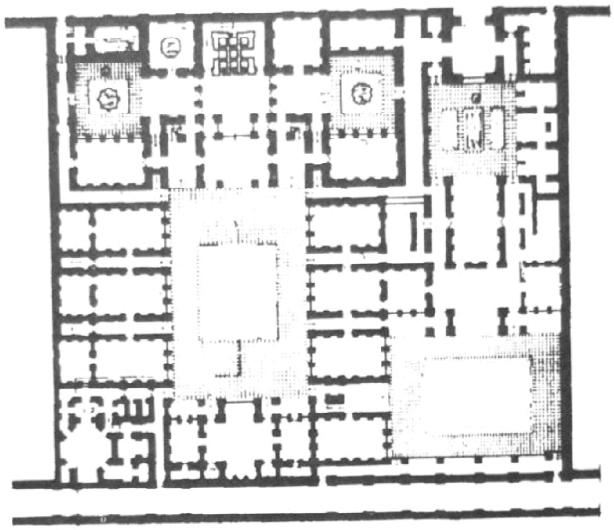

Figure 6: Using fractal geometry in Iranian residential building. Similar squares in different sizes.

The best example of a fractal is when the multiplying occurs in a way that the final form is similar to the original. In another word, they repeat themselves. The more similar the original with the final form the better they are. Barnsley fern and snowflakes are the best examples for this order.

With a look in these forms we find out that they exist and change naturally. An important part of Iranian architecture, being Iranian bazar and house, are created based upon fractal properties, like repetition, multiplying and change in form of squares. What repeats in this geometric structure is a repetition of similar yet different in size squares which have multiplied along the diameter in a symmetrical pattern. An important point in this architecture is a similarity between the ultimate form of the plan with consisting elements, like it has repeated itself.

Orientation in Residential Architecture

In Iranian residential architecture orientation is very important. That is, it is devised according to geographical properties and the side of the sunshine and winds (pleasant and unpleasant ones) and qualities of the soil. Three basic sides are: NE-NW, for cities like Tehran, Yazd, Jahrom, and Tabriz in North of Iran, Isfahani (NW-NE), for Isfahan, Estakhr, Shiraz,… and Kermani (East-West) for cities like Kerman, Hamedan, Azerbaijan Qarbi, Khoi,…

Buildings Side in Four Geographical Realms for Iran

In each of geographical realms of Iran the side and the yards are places as follows:

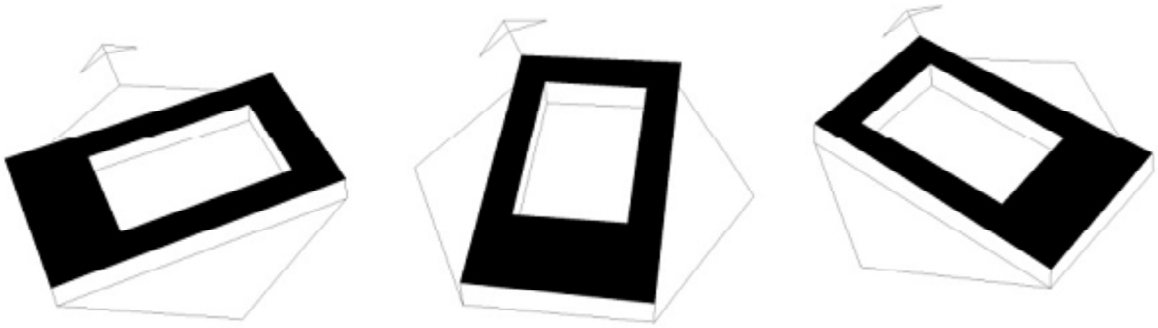

Figure 7: Side in Iranian Architecture

Hot regions: In Isfahan and Yazd all four yards are made in a way to have the utmost use of shades of the buildings.Here the best side for the sunshine is South and south-east. And northern spaces are the ideal ones for the cold months.

Moderate and humid regions: The residential building is in the center of the yard. We can conclude from the table that because of the need to absorb the sunlight, most spaces are made in northern side, this also helps air movement in the building.

Cold and dry regions: In this region we need to have the most amount of sunlight in the winter and the least absorbed heat in the summer. The main building is located in the north to absorb the most sun heat. The south is empty or the storehouse. On the west or east of the building there are residential spaces, which vary in different cases.

Warm and humid region: The building is located in the center of the yard to use most to the shade of the building possible. In Bandar lenge, we saw that most of the residential area is located in the north, which is the best to absorb sunlight and it is in the same side with strong wind currents.

Order and proportion systems in Iranian architecture

In Iranian architecture there have always been special proportions. One can say that the oldest Iranian proportions are found in architectural elements. These proportions are divided two groups of golden proportions and touchstones (peymun).

Irnian Golden Proportion

This proportion is related to $\sqrt{2} = 1/41$and $\sqrt{3} = 1/73$. And it was used in ancient architecture of Iran. Professor Pirnia calls this the golden proportion. Examples for this proportion exist in Apadana palace, Perspolis, Kasra Palace in Tisfun and Sarvestan palace.

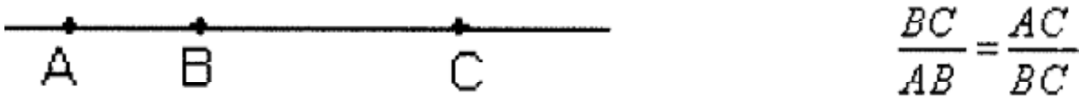

Figure 8: Golden proportion on a segment

1.1 In Persepolis, and especially in Apadana Palace $\sqrt{2}$ has been used. The middle hall has been considered as the basic square and its diameters are used to determine the diameter of the pillars.

1.2 In middle hall in Kasra palace they used 1/73.

1.3 Also, 1/118 which is derived from the golden proportion used to be applied before Islam. Examples of this exist in the lengths of Sarvestan palace and Kasra palace both from Sassanid era.

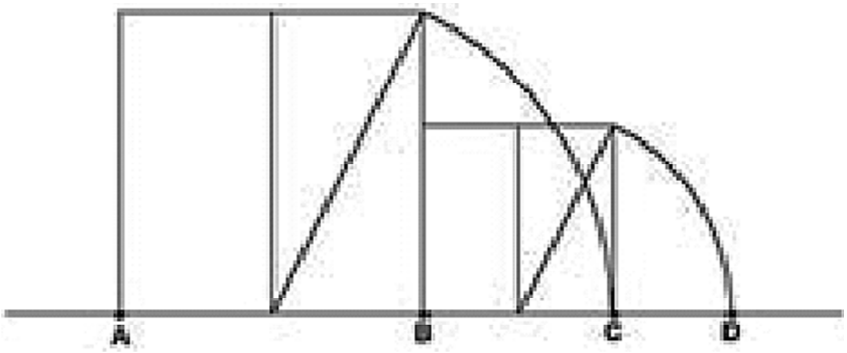

Figure 9: How to make a golden proportion with a square

Beak and add: today it is called Zad o khord, was used in proportion system in the past. It means removing from one and adding to another. Of course the amounts are small.

Peymun in Residential Architecture

Our architecture contains many interesting points. One of them is peymun. Peymun means touchstone. It guarantees proper size and proportions in buildings. Iranian architects used this to link different elements and hence create a harmonic piece of art. People used peymun in the past for different reasons. They were small touchstones that assured the architects that there would be no inequality and anti-aesthetic quality in the building, just like a skilled master.

Architects used different numbers of peymuns so they made very different buildings using the same touchstones, and this made buildings unique.

As Prof. Pirnia says “About peymun we can say that it enables organizing in traditional architecture using a specific norm. The architect, adds and omits and moves things to create proportion. Peymun not only is used as the basic size in designing it is also used to determine place of the pillars, Width and length of the rooms and halls and also provides the size of windows and façade and domes and doors and ledges, etc. It tells us how thick every part of a dome must be. Also, the height, form and angle are set according to the peymun. Usinf it the architect decides what to add or omit and build without worrying about disformities.

Table 1
Exact amounts of Peymun and Gaz

	Small peymun		*Big peymun*	
Elements	*Elements*	*Size(knot)*	*Size(cm)*	*Size(Gaz)*
Width of window	—-	14	93	18
	2	13	4	27
	9	60	9	60
	9	60	11	73
	28	186	30	200
	32	213	44	293
	48	320	66	440
	80	533	110	733

It is interesting that Iranian architects made very differen buildings using the same peymuns, just by the number of repetition. This is exactly the opposite of Greek temples which are quite identical.

Two peymuns are: Small peymun equivalent to 93cm and big one equivalent to 120cm.

The yorts: One door (hallways), two doors (small room), three doors (room), 5 doors (big room), hall, etc. Doors are used to control light in different seasons.

Also the sum of two jambs are 2 gere in small peymun and 4 gere in big peymun.

Three door room is usually the bedroom or sometimes the office. Architects devised spaces behind these rooms so that no one can enter the room from the yard immediately. In small peymun the width of the room is 3.2 meters and the doors are 4 gere wide. Doors are 2 gere away from each other,and they are 1 gere away from the wall.

If the owner needed a bigger room the architect used the big peymun so that the width of the room would be 4.4 m and doors were 1.2 m wide and doors were selected 2 meters. If they used small peymun it would be 1.87 meters high instead. In this pattern areas are appropriate and different proportions are brought into consideration.

Geometry and its Effect on Residential Buildings

Every constructional system is a part of a bigger system that is architecture. SO a construction should not only act as a construction but also it must be in the path of architectural aim. All constructions must follow this rule. Every construction is related to three other concepts in architectural realm, they are: form, function and meaning. Coverings were also considered in traditional architecture. On the contrary to nowadays architecture where constructs and architecture are thought of as differentin the past architects had to consider everything from building to decoration. As they made buildings they thought about covering simultaneously.

Covering requires measuring openings and weight and forces and changes and walls and height of the building and etc. which are all related to using the peymun. And these all were done at the time of constructing the building.

CONCLUSION

In the past great architects tried a lot to use mathematics and geometry in architecture. Geometry was so important that only high level scholars were called engineers. The highest duty of an architect was to identify and understand Inertial and the current forces in a building which was calculated by means of a mastery over proportion and size of full and empty spaces.

There are obvious reasons for using geometry in Iranian architecture. From the outside, it is an art to create shapes and patterns and proportions which reminds us of the creations by God. Geometry is a key element to link between the building and the architect’s intellect. From the inside, it is a science that helps to choose the proper size, length, width and height and to know the influence of materials on the construction. A geometric approach leads to a functional building. Elements that influence residential buildings are size of the area, foundation, geometry of the area and natural elements.

Residential buildings are divided into two groups according to geometric patterns; Char-saffe and Miansara-dar. The latter is more common in very big houses that have yards and nobility used it. Char-saffe is more common in smaller houses and being small is a beautiful and architectural pattern.

Iranian houses just like any other Iranian buildings had specific order and symmetry. Of course there are examples in which because of the quality of the land and geographical limitations there is no symmetry. But we can see symmetry in all yards. This symmetry is totally in accordance with Fractal theories and different repetitive surfaces create a space called a building by means of symmetry and proportion.

In proportions we come across a term which is the touchstone (peymun). Touchstone (peymun) is a means to regulate size and dimensions. We have two types of touchstone (peymun)s, the big one and the small one. It is used in size and dimension and pillars and widths and room sizes. Also, it regulates windows and façade and doors. In all the phases of creating an architectural elements geometry and touchstone (gaz and peymun) are present. Geometry and construction by means of touchstones and controlling the size create the desired result.