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The Application of Golden Proportion in the Façades & Ornaments of Quadruple Vaulted Porticos of Jami Mosque in Isfahan, Iran

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ABSTRACT: Various investigations have been carried out about the Jami mosque of Isfahan before and each of them considered analyzing a part of assets of this magnificent arte fact. A part of these studies focused on the building fabric and resulted in the pathology of this building. A group of published works have been concentrated on the architectural styles of the building and its evolution through the various reigns of Iranian kings. Arthur pope and Andre Godard analyzed the shapes and styles of the building before and after Islam. Recent researches have also been carried out more about the brick laying systems of vaults, brick ornaments, tile works and plastering. However not enough research has been done about the aesthetic aspects and using golden proportion in the facades and quadruple vaulted porticos of this mosque. A comprehensive study about the golden ratio and golden proportion which is rooted in the Fibonacci series has led towards a geometrical shape which has been used as a standard measure to check the existence of any employment of golden ratio. Placing this standard shape over the arches of vaults in facades according to the scale of the maps revealed the usage of golden proportion in them. Architects and master builders of this mosque were aware of the adjunctions to the building throughout history and were trying to create coordination and harmony between various parts by using proportion systems.

Keywords: proportion, golden proportion, Jami mosque of Isfahan, portico, façade

INTRODUCTION

Ratio and especially golden proportion have many different aspects and functions in science and different courses, mainly the courses related to building and architecture have vastly benefitted from this ratio. This ratio has had different names including the sacred geometry, modular, Persian Peymoon, etc. in different times. As an important indicator of Islamic period monuments, mosques have always been paid attention by Muslims. Therefore, Isfahan Jami Mosque, as a unique architectural museum of different historical periods, owns values and characteristics whose study would increase our knowledge of those periods and their architecture.

RESEARCH METHOD

Regarding nature of the research subject, it is a historical-descriptive research and the information is gathered by using the documents and field method. After conducting surveys and carrying out general studies present in literature of the field of proportion and ratio, the principles of using this mathematical relation, especially in architecture, were described. Through geometrical drawing of standard mathematical ratios present in golden ratio, a basic form was achieved; then

using comparative and adjustment method, the utilization of golden ratio in scales of the existing maps of porches and vault's arch was certified.

RESEARCH BACKGROUND

Lots of studies and researches have been conducted concerning Isfahan Jami Mosque, in which different aspects of it have been clarified. These studies may be considered in the following sections:

1. Activities by ISMEO and scientists like Professor Eric Schroeder (1904-1971) which are based on architectural studies, searching in monument body and breaks existing in the monument, excavation in floors and foundations and preparation of photogrammetric and manual brick-to-brick map.

2. Other studies by scientists such as Arthur Pope (1881-1969), André Godard (1881-1965), Erich Schmidt (1897-1964) and Donald Wilber (1907-1997) consider good recognition of Iranian architecture and its analysis regarding its formation in pre-Islamic or post-Islamic times.

3. Iranian experts and supervisors engaged mostly in restoration actions and their reports about repair works

and the necessities required in Jami Mosque are of special importance. Some of these scientists are: M.T.Mostafavi (1905-1980) (father of new restoration works in Iran), Dr.L. Honarfar (1910-2006), professor B. Ayatollah Zadeh Shirazi (1936-2007) and Dr. A. Jebelameli (1941).

In addition, studies are conducted in universities and mostly in the fields of discovering structural characteristics such as vaults (Besenval, 2000), arches and brick decoration, tile-work (Pour Naderi, 2008) and plaster works of Jami Mosque.

In spite of all these studies, issues such as ratios which should be studied technically have been neglected. It is attempted in this research to study the facades and porches of Jami Mosque of Isfahan more precisely, the goal of which is to answer the question "whether golden ratio have any place in architectural construction of this mosque or not".

METHODOLOGY

Ratio

Ratio is the comparison between two qualities or two quantities such as size or amount; therefore, ratios are considered as proof of a difference or disparity. "These differences at least inspire one of the senses of human. Ratio is relation between two homogeneous objects, in which following the comparison, their condition to one another is clarified "(Issam, 1999, 19).

Proportion: $\dfrac{a}{b}$

Ratio: $\dfrac{a}{b} = \dfrac{c}{d}$

Ratio Systems in Architecture

Throughout history, different proportion and ratios are used in architecture all of which aim to create a sense of order and harmony among elements of a visual layout. The ordering system of ratios, create a set of fixed visual ratios among elements of a monument and between the elements and whole monument. Even though, these ratios might be ignored the first time a visitor looks at them, but the visual order created by them is felt and recognized. Ratio, in architecture, is related to order concept, due to the concepts of rhythm and harmonic space. A proportionate rhythm might be a simple relation: a.b.a.b.a or a more complicated one. "Ordering systems of ratios are more than simple determinant functional and technical elements of architecture space which provide aesthetical relation between dimensions and sizes" (Lang, 2003, 216). There have been different ideas and theories about ratios throughout history; in spite of some differences, ratio orders during ancient, renaissance and modern times have been all based on mathematics. At present time, "modular systems and the expression of architectural ratios show that planning based on them includes sizes and proportionate distance between construction elements" (Neufert, 2004, 34).

Golden Ratio

Mathematical systems of ration are derived from Pythagoras theory which says: "everything is number and based on this idea some numerical ratios state the harmonic structure of universe" (Ching, 2008, 292). The origin of ratios, especially golden ratios can be searched and found in nature; science has proved that this ratio is really the base ratio and basis of universe creation. This ratio is seen in primary forms of nature, flowers, virus structures, DNA, snails and galaxies. "Golden ratio was not primarily a number, but its numerical value is also proved by mathematics" (Hejazi, 2005, 1417).

$$\phi = \frac{1+\sqrt{5}}{2} = 1.618$$

Golden ratios are achieved geometrically as follows (Figure 1).
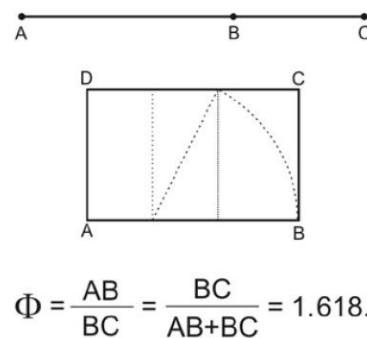
$$\Phi = \frac{AB}{BC} = \frac{BC}{AB+BC} = 1.618...$$

Figure 1. Geometrical structure of golden ratios (Ching, 1991, 300)

Most of the monuments, where golden ratios are used, have become well-known and lasting monuments, which according to most experts the reason lies in using these ratios – which are also called sacred geometry.

DISCUSSION

Ratios in Iranian Architecture

Throughout Islamic period, using ratios in art and architecture of monuments, especially the monuments constructed for religious functions meant combination of science and art with natural, heavenly and divine origin. By means of combining this art to heavenly origin another world is created to the artist: a world full of secrets and mystery; in harmony and under the rule of a creator. This heavenly connection introduce most of the subjects as the goal of semantic art; which in case of architecture its materialistic base is the architect's technique and the science which deals with it is geometry (Memarian, 2008). In addition, in Islamic period, it is believed that order and ratio are the natural and universal laws and human being has to understand their process by calculation, geometry and harmony. Traditional architecture can be considered as an element of expanding the basic principal of deforming a circle into a square using triangle. Square is the most embodied shape of creation in earthly level resembling quantity, while circle in heavenly level resembles quality and these two merge into one via triangle which guarantees both aspects. Mojabi's 2008 study advocates: The shape and form of traditional buildings of Iran follow

geometries of both physics and mathematics and in fact it is a combination and modulation of two kinds of spatial understanding. The balance and static of the shapes in this architecture is derived from these two bases. Form, in this architecture, is the result of materialistic and physical structures (p. 56).

Iranian architecture always paid most attention to positive aspects of architecture, human scale, ratios, etc. and "calculations and geometry were so important that only first-class architects were called scientists and engineers" (Pirnia, 2006, 46). *Mardomvari* or *People-like* in this concept means considering the analogy between buildings' body and human body and considering his needs in building construction. One of the instruments used and considered to make a monument "people-like", in Iranian architecture, is called Peymoon. Peymoon is a basic size which sizes of all sections, building body and every space is calculated based on that and it does not only affect the place of columns, width and length of rooms and corridors but also clarifies the façade shape, door and windows and their ratio and above all it is well utilized in covering doorways, porches, vaults and dome houses (Pirnia, 2009). In Iranian architecture, Peymoon had small and identical sizes which had to be used in suitable places. Utilizing Peymoon, removed any anxiety from the architect about ugliness and unstableness of the monument.

Jami Mosque of Isfahan

Among the intra-city bodies of each city and village in Iran, worship places had always special position and were more dominant and egregious than other bodies, in a way that without having any special emblem they were always considered as the most proposed element of city or village. During post Islamic period, big mosques were more important than any other Islamic architectural elements. Galdieri (1992) approves: "City-village of Isfahan accepted Islam in 645 AD and owned mosque and minbar, but the born of centralized Isfahan city was simultaneous to construction of Isfahan Jami Mosque in 773 AD. Since that time this mosque, as a religious, scientific, social and political center, became a place to reflect the city evolutions of the city in later periods" (p. preface). This monument which is also known as *Atigh* Mosque and *Friday* Mosque, is situated in the ending part of Big Bazaar of Isfahan and it is one of the outstanding architectural works of Iran and the world. Since its different parts are constructed in different historical periods using different architectural techniques, the present complex seems like a great museum introducing the process of evolution and completion of Iranian architecture in Islamic period. The remains of its architecture relates to the times from Abbasid Caliphate to Dailamites periods, Seljuk, Ilkhanate, Muzaffarids and Safavid dynasty, each of which sharing a part in its construction.

Along with history, Jami mosque of Isfahan has faced many changes and many extensions are added to it. But, the most important change occurred in Seljuk time, when the *Shabistan* pattern of the mosque was changed into a four-porch pattern. In any of each four side of the mosque, there are glorious façades, ornaments and a great porch.

Façade Ratios and Vaulted Porticos of Porches

In this section, dealing with studying the ratios used in facades and quadruplet porches of Isfahan Jami Mosque, comparing them with the golden ratios, is mentioned. To achieve this goal, firstly the approach of golden ratio for motion based on number ratio and then ratio of lines and finally the ratio of figures are being discussed.

As it is seen in Figure 2, Fibonacci sequence (series) (Fig. I), except 3 first sentences – which are considered exception in this sequence – follow the golden ratio. Similarly, in terms of geometry this ratio (Fig. II) can be defined as a divided line in which the proportion between the small part and the large part of the line equals the proportion between the large part and the whole length of the line (Fig. I). In the third stage (Fig. III), after the circle is divided to five equal parts, the points obtained are connected to their adjacent points –and in such a state a regular pentagon will be obtained-; furthermore, if the points of this pentagon are connected to one another two by two, a pentagram will be obtained within which there will be another pentagon. In this state, the line segment "a" together with "b" will form a golden ratio. By further expanding mathematics and geometry several figures can be obtained, all of which possess golden ratios.
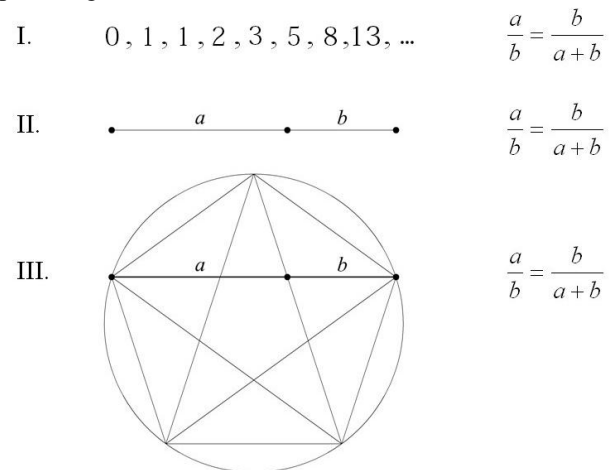
I. $\qquad 0, 1, 1, 2, 3, 5, 8, 13, …$ $\qquad \dfrac{a}{b} = \dfrac{b}{a+b}$

II. $\qquad$ $\dfrac{a}{b} = \dfrac{b}{a+b}$

III. $\qquad$ $\dfrac{a}{b} = \dfrac{b}{a+b}$

Figure 2. Formation of golden terms of geometry (author's drawing)

Now the geometric figure mentioned (Figure III) can be used as a criterion to identify ratios. Therefore, here the existence or nonexistence of golden ratios in the mosque can be found by matching it (the figure) with the quadruplet facades of Jami Mosque. It should be noted that the plan of all facades used in this survey have been extracted from "Ganjnameh" (Haji Ghasemi, 2004).
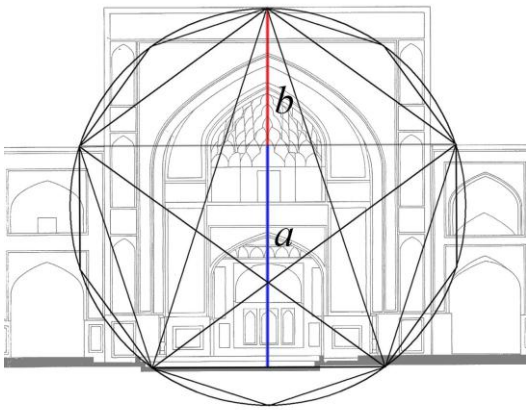
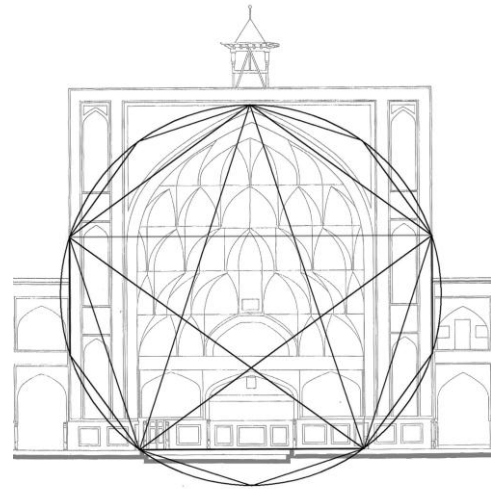**Figure 3.** Golden ratio of Northern porch
(author's drawing)

Figure 4. Golden ratio of Eastern porch
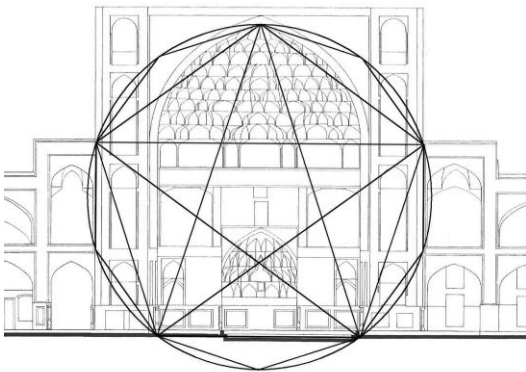(author's drawing)

Figure 5. Golden ratio of Southern porch
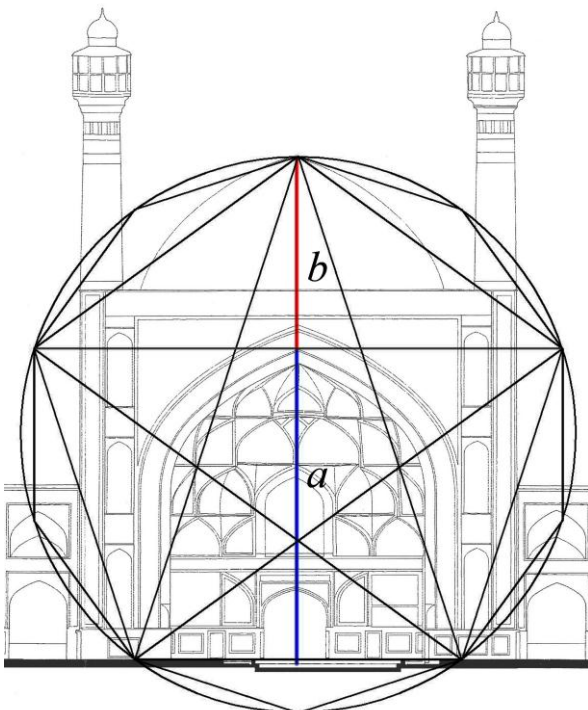(author's drawing)

Figure 6. Golden ratio of Western porch
(author's drawing)

Application of golden ratio in porches can be discovered by casting a glance at them, in a way that through matching the figure with the golden ratio (Figure 3) on the north of porch, height points of porch and height of vaulted porticos in Figure 3, pointed vault, height of vaulted porticos and width of porch in Figure 4, pointed height of dome in Figure 5, and height of pointed vault and width of porch in Fig. 6 are obtained respectively. In addition, the golden proportion can also be observed in vaulted porticos of the mosque (Figure 7).
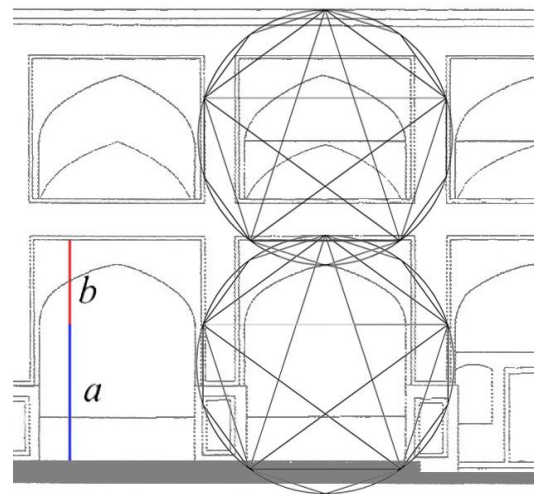

Figure 7. Golden ratio of facades and vaulted porticos
(author's drawing)

As it is also seen in Figure 7, the golden ratio is used in facades and vaulted porticos of Isfahan Jami Mosque in such a way that the vault span, distance between the two vaults as well as vault height follow this ratio.

CONCLUSION

In Islamic period and the following years, the usage of decorating elements like pictures of creatures and living things in religious monuments, especially mosques was forbidden. This made Muslims find a new solution for embellishing their worshiping places. Therefore, by getting help from mathematics and Fibonacci sequence they made effort to obviate it. The application of this mathematics has caused some scientists and researchers to consider the Fibonacci series and its derivatives as the foundation of Islamic geometry.

Considering what was explained, this mosque was built in consecutive years and in each period some parts were added to it. Using golden proportions in porches and facades is one of the measures which have made a kind of unity be observed in all facades. In other words, one can say that being informed of the geometric structure of golden proportion, the architects and master builders of this mosque attempted to create a kind of harmony in porches and facades through application of golden ratio. Such a claim seems justifiable considering what was discussed already, the drawings performed and the studies carried out as well.

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