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Research Article

HIDDEN GEOMETRY OF BUILDING ALI QAPU OF ISFAHAN IN DETERMINING THE GEOMETRIC RELATIONSHIP WITH NAGHSH JAHAN SQUARE

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ABSTRACT
View, plan and generally form of an architectural structure is born of mentality that in the complex network of relationships, needs, relationships, goals and objectives has created, grown and developed. We consider the most important factors that form functionally and determine the architectural form of the Safavi palaces, the social and political organizations of the era and discuss conformity of the geometry and the placement of the building in Square. Iranian architecture always accent on the beauty and Iranians have tried to employ coordination in dimensions of building that reflect the golden ratio and cosmic relationships. Ali Qapu House is the mansion is located in the West of the Naghsh Jahan Square, and in front of the Sheikh Lotfollah Mosque, and as one of the most important architectural masterpieces of early eleventh century AD has a universal reputation. The palace was the central gate and entrance of all the mansions that in the Safavi era in the area of Naghsh Jahan Square was built. Ali Qapu is composed of two words, Ali and Qapu, which together mean "head high" or "high port". Geometric analysis the building of Ali Qapu reveals some belief that is effective on design of the important building, such as the golden ratio. The mansion on the west side of Naghsh Jahan square is established based on the golden ratio. In this paper, based on the hypothesis, that there is a definite geometric relationship between the placement and geometry of the plane, first plan the geometric model, and then with adapt it to the building construction plan prove the hypothesis, and apparent part of a logical development of the effect. Methods In this paper is analytical-descriptive, and with the geometric structure analysis, the conclusion is reached. First images, plan and location of building has presented and with its geometric analysis, the hypothesis has been proved.

Keywords: *Safavi Architecture, Ali Qapu Palace, Golden Ratio, Golden Ratio*

INTRODUCTION
Palaces architecture of the Safavi period is considered generally from an aesthetic perspective (Rafiei *et al.*, 1973), and less space analysis and form of architecture are discussed. In analysis the form of a work of architecture, the characteristics including the plan, facade and different spaces are studied, and to find the relationship between these elements, the speculation will be discussed. For example, the construction of the mosque than the building such as a hospital far deeper accept impact of belief, or impact of political organization on the physical form of governmental structure, such as the Citadel is greater than the impact of economic organization to form the structure. Understanding proportions inevitably reach to period far and even before that date. Islamic art in terms of its history has been extensive studies, but in the study of its art methods, which involve scientific research and technical mastery, except for the few, not taken into consideration. Bastani *et al.*, (1988) in the regulate space of geometry which everything including parts of a house, and even a city can walk into circle of world, and in the space of plurality and variety find their own identity. Fundamental factor in creating unity among the components of the universe and including in body parts, each of architecture cultures, could not be anything except geometry. Parman *et al.*, (2010) geometric analysis of many of the monuments of Iran, proved that in Persian architecture, thorough knowledge of fitness, particularly golden ratio is widely used, and the aesthetics of Iran. In many buildings in Iran, plan and vertical section, in the framework of squares and Equilateral triangles was designed, which hit their dungeons determine all major fixed points, such as the width and height of doors, width, length and height of the buildings, the inscriptions, etc. Therefore, the size of each item by a

certain proportion was related to other item. As a result, a building was not a set of heterogeneous components, but, harmonious combination of components with appropriate connections, which give moves to space and calm to eyes. Ching *et al.*, (2007) by study the architecture of royal and aristocratic residences can realize in addition to the deep class divisions in the nature of political power in the government, in Safavi Persia. Ching *et al.*, (1989) architecture provides a visual expression of ideas, ideas that are meaningful to the human phenomena. In fact, the ideas give reality. Such ideas perhaps are social, professional, scientific, philosophical or religious materials (Hejari *et al.*, 2008). Safavi palaces also are not exempt from this rule. Form and geometry of the Safavi palaces is metaphorical expression of the nature of government entity, and its relationship to other social institutions. Government entity, as a social organization is a series of settlements or places of behavior, which has somewhat clear, normative order, classified responsibilities, communication system, and the planned system, and is composed of a set of current patterns of behavior and physical environment (Hejazi *et al.*, 2008). Of the most important of Safavi era palaces, which is indicative of the above descriptions is the House of Ali Qapu. In this article, an attempt is to analyze geometric architecture of building Sheikh Lotfollah Mosque is apparent the architect of some of the decisions in the creation of this beautiful and lasting effect (Figure 1)

Figure 1: The Mansion Ali Qapu, Naghsh Jahan Square, Isfahan, Iran. source: Author

MATERIALS AND METHODS

Ali Qapu Building: Location of Building and Design of Problem

Ali Qapu House is the mansion is located in the West of Naghsh Jahan Square, and in front of the Sheikh Lotfollah Mosque, and as one of the most important architectural masterpieces of early eleventh century AD has a universal reputation. The construction date of building returns to1054 AD and its founder is Shah Abbas. The palace is main gate, and the entrance was all the mansions, in the Safavi dynasty, in Naghsh Jahan square, were built. Ali Qapu composed of two words Ali and Qapu, which together mean "head high" or "high port". Other names of it are Ali Qapu, home state of Naghsh Jahan, and home government palace. Ali Qapu has five floors that each floor has a unique decoration. On the ground floor, there are two halls, which in those days were dedicated to the Administrative Court, on the third floor is large patio, which is based on eighteen columns, is tall and lofty, and in the middle of the patio, there is beauty pool of marble (Figure 1) in general, Ali Qapu building, as a ceremonial monument, well-made and beautiful is another achievement of the architecture art of Safavi period, which is above it, the vision of ancient city of Isfahan, and its 1000-year change is well visible. The position of the building, on the

west side of the square, based on a determined geometry was located, so that the location of the entrance has divided a side of the square to the two golden proportion relative to each other, which its geometric analysis express in the another part of this article. But what is important in this study, is whether that locating the building to the whole Naghsh Jahan square (the body of square) follows certain principles? Which method is chosen Geometry and facade design and construction plan? Galdiri studies (from 1964 AD to ten years) speak five successive stages of development. (Figure 2) that he believes its start was along with the construction palaces, and the building, which was in the midst of lush gardens, and was surrounded by a fence. Extensive collection focused on ceremonial, administrative, judicial and retrieval activities. He has introduced first building phase, in the form of a cube, big and heavy with dimensions 19 × 20 in height13 m, which since the era of Shah Abbas I, and four other stages, the reign of Shah Abbas II, has gradually been completed (Mehrabadi *et al.*, 1973). Galdiri, extending vertically to change the face of the Square, and longer breaks were noted, and columned hall's accession, the "Shah Abbas II", and add or intervention in the eastern facade to the "Shah Sultan Hussein" is attributed.

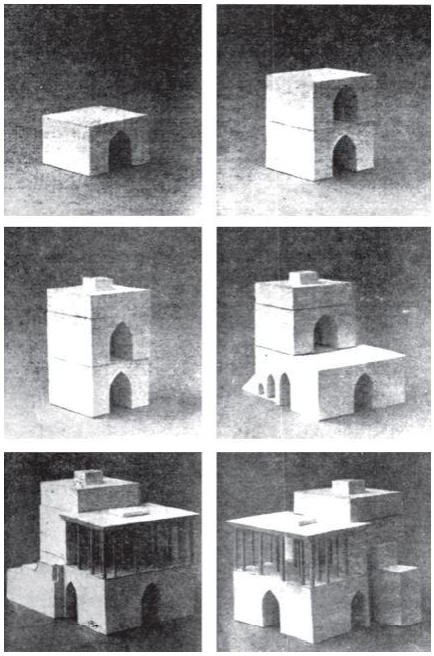

Figure 2: The construction of the building Ali Qapu in Galdiri theory

Building form Ali Qapu

Simultaneously with the construction of Naghsh Jahan square, Ali Qapu building construction begin, and at first, as the gateway to Royal neighborhood, was used (Aliabadi *et al.*, 2007). Where the court building, and governance center, alongside social and economic center of the capital, was not devoid of purpose. Shah Abbas intense supervision on market and economic system (Clark *et al.*, 2000) needed feel his presence in the community. Ali Qapu building made to meet the goal, and the symbol of sovereignty in the most compact population center, monitoring of king on subjects was induced. House view Ali Qapu hierarchical approach, compared to neighboring and discontinuity in visual and spatial continuity and creates a differentiation and fragmentation in the importance of the palace to the adjacent spaces (Galdiri *et al.*, 1983) Patterns of organization of form and space describe with terms which include: focus, linear, cluster, the center, nesting, two centers and two nuclear organizing (Galdiri *et al.*, 1983) which each based on the performance of building are employed in the design of form. By examining in the plan and building facade Ali Qapu, it can introduce the organization with focused instruments. Requisite of central forms is the visual superiority of regular geometric form (Lang *et al.*, 2002), which form of the foundation of Ali Qapu has this trait, and regular geometry of the building is visible.

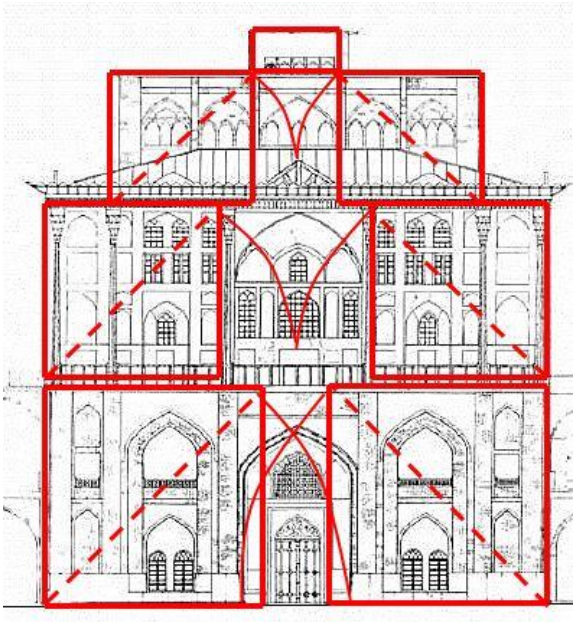

Figure 3: Regular geometry in view of the mansion Ali Qapu

Pattern of Work

It is composed of two stages:

1. Positioning Ali Qapu building, on the west side of the Naghsh Jahan square.
2. Geometric analysis of facade and plan of building that of the golden ratio is modeled.

By comparing the results of the above steps, the location and hidden geometry of the mansion is proven. Therefore, a brief of golden proportion, golden ratio is told here.

Geometric methods of construction of the golden ratio: golden proportion- golden ratio, divine ratio, divine proportion, sacred cutting - the symbol Φ is shown, in the form of plants, flowers, viruses, DNA molecules, shells, planets and galaxies can be seen. It seems like Phidias (about 490-430 BC), Athenian sculptor of the golden ratio has used in his work. Golden ratio is approximately equal to 1/618. Golden ratio is the unique ratio of two parts, when the ratio of the larger part to the smaller part is equal to the sum of two parts to the larger part. This ratio is the symbol of rebirth, and the progression and expansion of the unit, because every birth is associated with before. Golden ratio is manifestation of divide the full of the unit (Norberg-Schulz *et al.*, 2003).

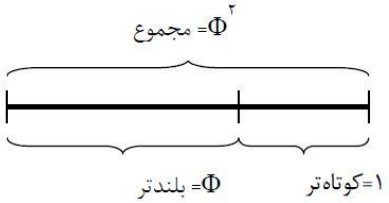

Figure 4: The Golden Ratio. Source: (article sacred geometry in nature and Persian architecture, by M. Hijazi)

The Golden Ratio is the most gratifying of aesthetic proportion. Throughout the history of art and architecture, traditional artists take God proportion as the Bible and fit of the aesthetic to embody the spirit of the matter. This ratio is compliance with the Great Pyramid of Egypt. The plan of Parthenon on the Acropolis is surrounded by golden rectangle, and include a large number of golden rectangles (rectangles with sides of relative length to 1 and Φ), which is based on the ratio.

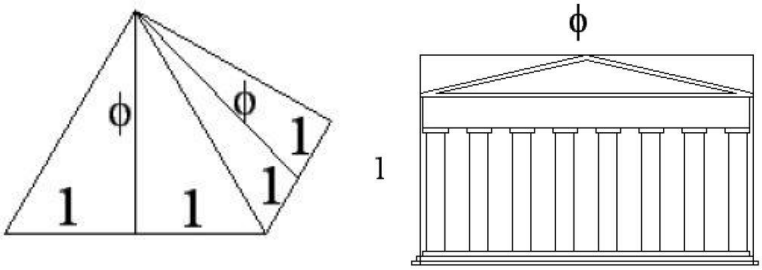

Figure 5: The Golden ratio of Great Pyramid of Egypt and the Parthenon. Source: (article sacred geometry in nature and Persian architecture, by M. Hijazi)

From the aesthetics the building Ali Qapu in Isfahan also shows the application of the golden ratio in architecture. If the width of building is considered as a unit, hotspots, such as the corners of the main entrance to the building and heights of different classes are instances of the golden ratio. (Figure 6)

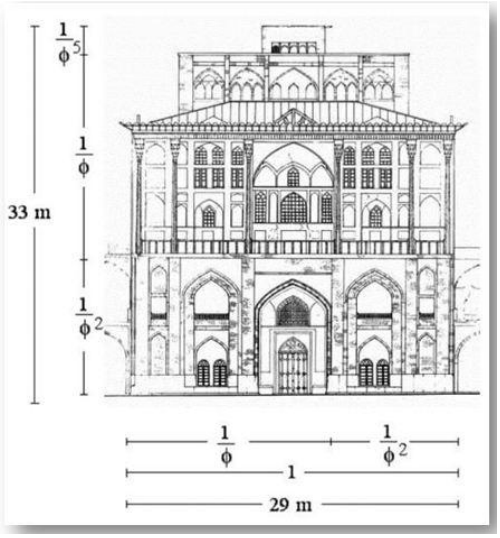

Figure 6: The Golden ratio of Ali Qapu Palace, Source: Base map from Galdiri

Geometric Methods of Construction of the Golden Ratio

Golden ratio with number of geometric graphics can be manufactured (Golden ratio, to divide a segment into two unequal parts, so that the ratio of the length of the shorter segment, the larger part of its length, equal to the ratio of the larger it is, the total length of a segment be defined? Golden Ratio, a Greek sculptor named "Phidias" and with the letter Ø display Ø:1, and numerically, is approximately equal to 1/618). In this paper, two methods, on the basis of the speech are provided. The first method shows how to make a rectangle with the golden ratio between the sides of a square. For this purpose, we first draw a square with sides equal to AB, and a diagonal line through the middle of the segment AB to the corner of the square in front of it is drawn. With radius equal to the line, and in the middle of the sides AB, draw the bow, to cut along the segment AB at point C. Rectangle with a length of AC, and a width equal to AB, will be a golden rectangle. By repeating this procedure, the golden ratio, along the line segment AB, will be repeated. Relationship CD: BC = BC: BD = BC: AB = AB: AC = 1: Ø between drawn components is established. (Figure 7) The second method shows how to divide a line segment to the golden ratio. For this purpose, first the segment AB is drawn. Rectangles of equal length AB, and width equal to AB / 2 and the diameter, the segment AD is drawn. By drawing an arc with center D and radius DB, the diameter of the rectangle is divided into two parts, the collision of arc to diameter AD. The final step, turning the larger diameter segment AD on the segment AB, which is drawn through the center A of the arc, and a

radius equal to the diameter of the larger piece, is performed. Point C is the junction of the Bow to the segment AB, the segment is divided into the golden ratio (Figure 8). Relationship CB: AC = AC: AB=1: Ø is established between components of line (Blake, 1999).

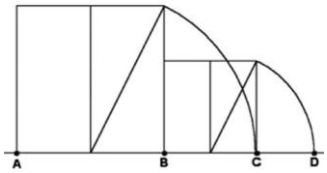

Figure 7: Construction of golden with square, Source: (Bvsvra and Mazvz, 2004)

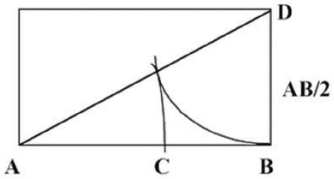

Figure 8: Method of dividing a line segment to the golden ratio, Source: (Bvsvra and Mazvz, 2004)

Positioning Ali Qapu Mansion, on the West Side of the Square

In this section, the method to obtain the location of Ali Qapu mansion, on the west side of the Naghsh Jahan square, we act according to Figure 9, as follows:

1. AC line segment equal to big part of the square, we draw.
2. In this case, the triangle ACD is achieved according to the image, so that the side CD is half the size side AC.
3. We draw an arc with center D and radius CD, and along the arc, chord AD, we cut at a point O.
4. Now another bow, AO radial distance from the center of A draw, which along this arc, side AC at point B cuts.

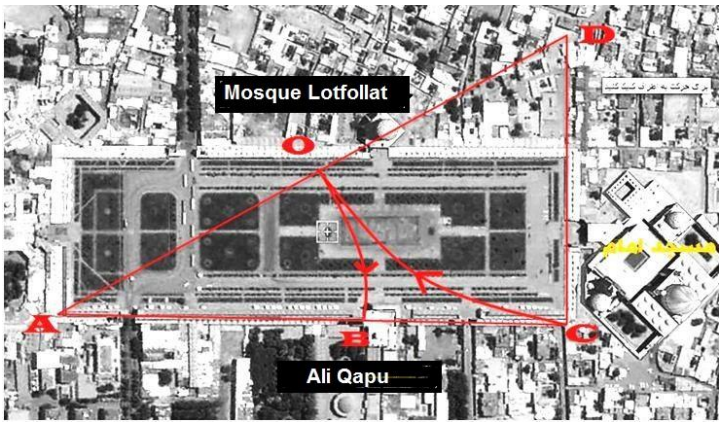

Figure 9: The proportion of gold in locating the building Ali Qapu than Naghsh Jahan Square, Isfahan, source: author

According to what was said, the B segment AC that is a large part of the Naghsh Jahan Square has been divided into two parts with the golden proportion. Relationship AB: BC = BC: AC = 1: Ø always true. Junction with the body of the building and point B is shown.

Ali Qapu Plane Geometry and its Relationship with Naghsh Jahan Square

In this section, the method to obtain the geometry, and the proportion of gold in the first floor plan of the building Ali Qapu we said, the point B, which you can see in Figure 10, the point is that in the last

analysis, according to the proportion of the Golden Naghsh Jahan Square is obtained, then the analysis will start from the same point, and we act as follows:

1. According to the golden proportion, we draw the line segment BF, and also the line segment EF, to obtain a triangle BEF draws.
2. Draw an arc with the center B and radius BF to cut the chord at G point.
3. Now draw another arc with the center E and radius EG to point H is achieved.
4. According to Figure 11, this symmetrical, side to side in front of BF do to the J point is achieved.

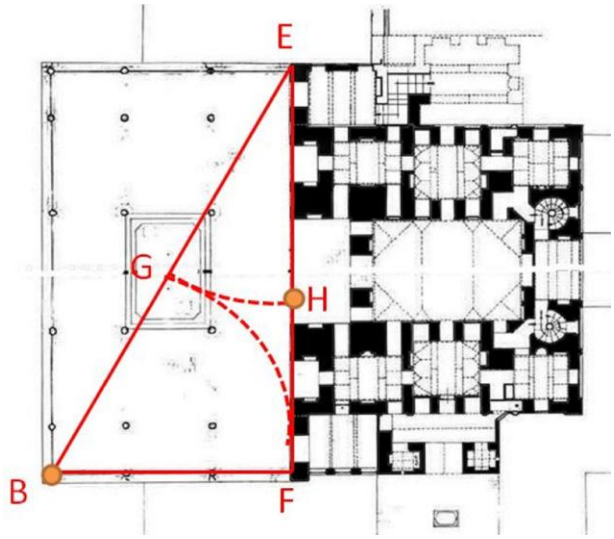

Figure 10: Proportion of gold hidden in determining the hidden geometry and communication plan with Naghsh Jahan Square, Isfahan

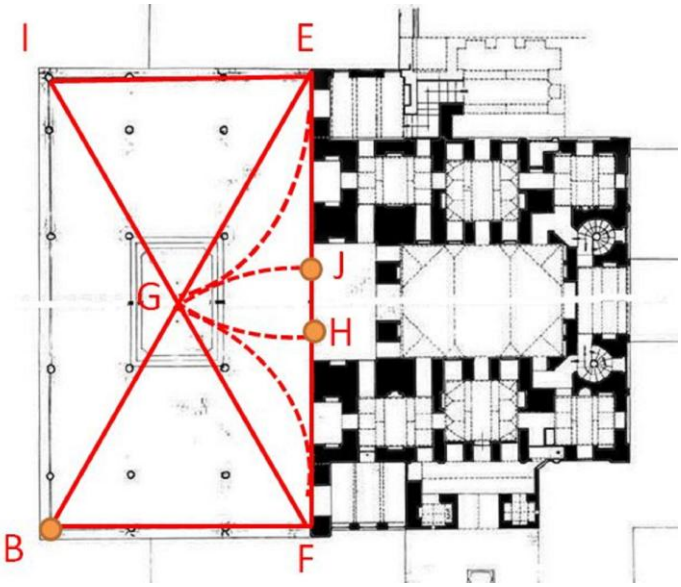

Figure11: Proportion of gold hidden in determining the hidden geometry and communication plan with Naghsh Jahan Square, Isfahan, Analysis Plan: Author

5. Now with the HJ, one side of the inner square of the plan we have, according to the same size, draw the square with respect to the size to the square LKJH obtained (Figure 12), then the proportion of gold, and drag the diameter of the square, we can draw an arc with a radius KH to obtain corner or plan the M point.

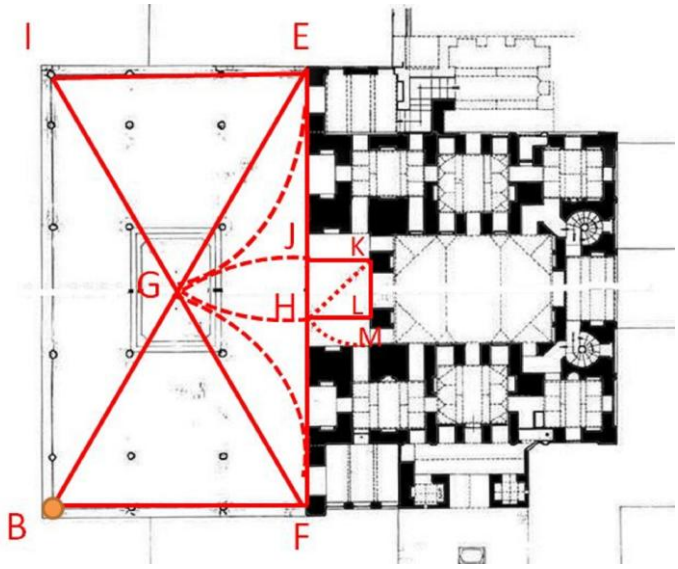

Figure 12: Proportion of gold hidden in determining the hidden geometry and communication plan with Naghsh Jahan Square, Isfahan, Analysis Plan: Author

6. According to Figure 13, the arc with the radius of MK and the center of M draw, to the point N, which is the starting point of the square, within the space of the original plan to show us.
We draw square NPQR, and then draw an arc with a radius of PR and center P, and we can see that the point S that is the other side of the interior plan will show to us. So you see, all the proportions of the plan, Set perfectly with the Golden, and easy can communication the proportion of gold inside with out, know in relation to each other (Figure 13)

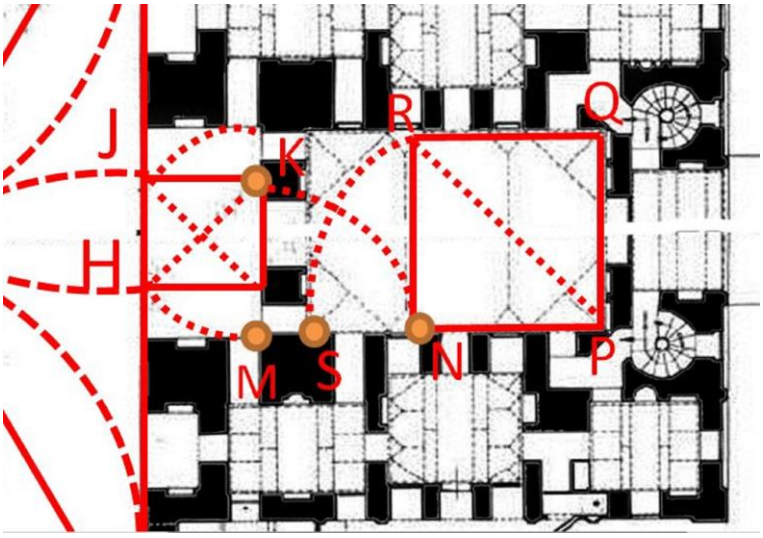

Figure 13: Proportion of gold hidden in determining the hidden geometry and communication plan with Naghsh Jahan Square, Isfahan, Analysis Plan: Author

On seeing this, we see in all different spaces, building Ali Qapu plan, a sense of proportion and beauty of the work, that kind of relationship with each other completely, and in this paper, we confine ourselves to the same size, but in Figure 14, it can be seen that geometry and fit of plane perfectly have relation with each other, to form a connection with the outside of the building, the Naghsh Jahan square is connected and understandable.

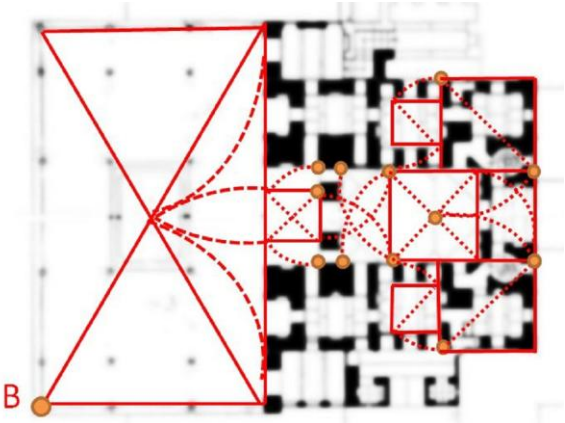

Figure 14: Proportion of gold, different parts of the building Ali Qapu plan, which are somehow related to each other, Analysis Plan: Author

RESULTS AND DISCUSSION

Results

By comparing the results obtained from the analysis is marked point B of the triangle BEF, which is located on the northern side building Ali Qapu plan is the junction space with the body of square. The point is, in fact, filed subscription plan interior, with the space of square, and the compliance proves coherence and appropriateness of the internal geometry building Ali Qapu plan, with the Naghsh Jahan square, perhaps can it is said fit of the Naghsh Jahan square and locating Ali Qapu building, in addition to the fit relatively smaller scale plan spaces has an interlocking relationship. Based on the analysis results, a plan that was designed interiors, a significant point that can be proven, the size and proportions of the interior plan in relation with the other spaces, the squares of the two sides of the plan which are symmetrically square LKJH, which was obtained from the analysis of space (Figure 14) have the same size, which indicates that the internal plan entirely based on the golden proportion, and in relation to its surrounding environment is designed, if the connection to continue the whole and vice versa, we can easily see it.

Conclusion

Central organization is balanced and focused composition on the center of a number of sub-areas, which often have gathered around a large central space, is formed. The general plan Ali Qapu, lateral spaces tend to see the central space.

In general in the organization, form of central space is the systematic unity, and it was so great that could be a number of sub spaces around itself to form. In Ali Qapu structure as a central organization, the sub-spaces of the form, size, and thus performance are similar, and overall composition emerged, which has a geometric regularity and symmetry are compared to one or more axes. Use the central form most of the buildings in order to flaunt the power and majesty of the king and courtiers, has been done.

In Ali Qapu House, administrative agencies and courts need to gather together, showing the apparent superiority on other structures and structural fitness with other structures of the Naghsh Jahan square, cause form, the center of mass is regular, the palace to his iconic role as king of the house, play well, but building Ali Qapu geometric analysis revealed some geometric relationships between the components of the structure by the Safavi period, the results are as follows:

• the position of the building, on the western side of the square, determined based on the golden proportion that the proportions continue to building plan and is a continuous stream.

• A proportion in view of the building can be seen, the proportion of gold used, which is the most beautiful proportions.

• Connect the internal geometry of the building plan, according to the analysis is completely continuous and interior plan with spaces for his side has a obvious connection, that not only the relationship of the plan, but this relationship, to the outside and square seen, which is seen as a systematic process.

The emphasis of Iranian architecture is on the beauty. Iranians over the centuries, has always placed a high premium on beauty and geometry is a powerful tool in the hands of an Iranian engineer, who uses it, it can measure the sky proportions and create balance, harmony, beauty and order on the ground. Ali Qapu mansion architecture with their complete understands on geometry in a masterly manner, which could to create complete harmony between inside and outside the building, and create the geometry and beauty proportion. Therefore, the geometry of the Iranian architect is both science and art.

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