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Investigating Geometric Proportions in The Design of Mausoleums in Contemporary Iran

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ABSTRACT

Mausoleum can be considered outstanding examples of culture, art and architecture. Every memorial work in the current context and historical conditions and the cultural, social, religious, economic and political requirements and requirements of the periods in which it was created is a living and active reality for the social groups and people who created it in their time. This research has been carried out with the aim of extracting and evaluating geometric proportional systems in the contemporary mausoleums of Iran. First, with a systematic review of the proportional extraction systems, and then it deals with the compilation of a conceptual framework. The research method is causal-comparative with a quantitative approach and using descriptive and inferential statistics. The sample size is selected according to the statistical population of 384 people. ORIGINPRO software is used for ease of obtaining results. results show that. At this stage, after extracting various geometric proportions, the selected mausoleums are evaluated. The results show that the greatest impact in the design of these buildings is the use of radical ratios with a value of (1.000) and the least related to Ken and Shako for components with a value of (0.167) for designers and (0.152) for users. In the section of general design, using the Platonic rectangle with a value of (0.914) for designers and (0.846) for spatial users has the greatest contribution in the formation of contemporary mausoleum designs.

Keywords: Geometric proportions, radical ratios, Ken and Shako, mausoleums, contemporary period.

1. Introduction

Due to its unique complexities, the matter of design, along with science and art, has an independent field of human knowledge. Design research, due to attention to interdisciplinary issues, challenges the structure of many universities that operate based on the division of knowledge. To reach the truth and what architecture is, it is necessary to study and know how people interact with the building and the world. Today, mausoleums are built to honor and remember various issues, such as an event character with the concept of great and great appreciation, these people, or to alleviate the tragic events that happened in different periods. visual, economic, political power, etc., they can have different scale and architecture, and memorial architecture can be divided into four categories: burial and non-burial, religious and non-religious. The importance of these buildings is their fundamental impact on the development and identity of many Iranian cities. which strengthens people's sense of place and belonging to these urban elements, which enhances the meaning and personality in today's cities and can become a symbol and identity of that city.

The issue of using proportions has been discussed since the beginning of human creation and his awareness of the issues and environment around him and has been researched and examined by various artists and scientists since the beginning of time. The purpose of all theories of proportions is to create a sense of order between the

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components of a visual composition [1]. Architects have succeeded in creating order, harmony, compliance with the principles of hierarchy and beauty in a set of buildings with different uses in the vicinity of each other by using good proportions and geometry throughout the ages [2]. Mathematical ratio systems originate from the Pythagorean hypothesis that says: Everything is a number and from the belief that some numerical ratios show the harmonious structure of the universe [3].

On the other hand, we know that most information is transferred to the human mind through the sense of sight and by seeing, and for this reason, the effects of visual experiences cannot be neglected in any way. In the theories of visual perception, the effects of this input information on the human mind and the mechanism of perception are discussed. But neglecting the effects of form on humans, the unfavorable quality of architectural spaces in terms of geometry, the change of values and geometric concepts over time and its ineffectiveness in contemporary times, individualism in design and not paying attention to intersubjectivity and interactive art in the design of buildings, lack of Paying attention to spiritual and psychological needs, economic and political conditions affecting the design, ignoring the proportions and appropriateness of these two for contemporary buildings has caused some contemporary buildings to gradually take on a chaotic appearance during the current century. Attention has not been paid to the visual messages that these forms and proportions leave on their audience, and one of the undesirable effects of this inattention is the lack of comfort and pleasantness of the audience in the space. In fact, today, the lack of a clear throughout plan or visual system, and at the same time being flexible and appropriate to the context, has become a wave of visual disturbances in many cities. These visual disturbances are like ambiguity in the form of a lack of physical visual continuity and a lack of visual connection between different urban areas in the view of today's cities. The result of these visual disturbances is the complexity of citizens' sense of identification and orientation in the city, and as a result, the lack of easy access to urban areas, especially in big cities.

This research has been formed with the aim of extracting geometrical proportions and the extent of their use in the formation of mausoleums, and it tries to answer the question that which of the available geometrical proportions have a stronger role in the formation of mausoleums?

Theoretical Foundations:

Definitions of geometry in the dictionary

The definition of geometry in the specific dictionary, the term geometry is expressed as the exponent of size and the action that is about the shapes of dimensions and the measurements discuss the meaning of certain cultures, under the geometry entry.[5]

The definition of geometry in Dehkhoda's dictionary in Arabic means size and shape. It is one of the principles of mathematical sciences and it is a science that discusses the states of quantities and sizes [6].

The definition of geometry in Pahlavi culture is the word geometry from the root of size and geometry is its multiplier.

In the small culture of the Pahlavi language, the root of the first geometrical concept was "peimanah", the first word is equal to the input of the earth and the second word is equal to the size.[7].

In Western texts, the root of the word geometry is known from geometers, which is Greek and means the specialty of geometry, and surveyor [8].

In other words, different definitions of geometry all emphasize the relationship between geometry and shapes and proportions. Therefore, the science of geometry is a powerful tool that has enabled the architect to measure spatial proportions and create balance, order, and beauty. Geometry plays an essential role in the design of architectural buildings. [9]. From the point of view of external performance, the use of geometry as art to create shapes, patterns, and proportions recalls the great architect of the universe (God). Therefore, the art of geometry is the key to creating a connection between the building and the ideas that the builder has in his mind. [10].

Table 1: Definitions of geometry and proportion.

Given definitions of geometry and proportion		
Concept	Size and shape	
Mathematics	geometry	Studying in space and imaginable shapes and objects in this space

	proportion	Proportionate relationship between components with each other and with the whole work
Architecture	Creating visual beauty, an inseparable part of the architectural space	

Geometric properties:

Circle and square are two key shapes in geometry that can provide real numbers and their combinations with the help of geometric drawings. A square has a quadrilateral, four sides and four axes of symmetry, two of which form the diameter of the square and the other two connect the middle of the opposite sides. The mentioned eight points and the center of the square have basic functions. [11] A rectangle also has this characteristic, but its diameters are not the center of symmetry and the distances of its opposite sides are different. Based on this, the functional value of the midpoints of the sides is not the same and the center of the rectangle has a weaker force and has the same distance compared to the square.[12].

Functional properties of the circle

One of the most important geometrical shapes, which in its symbolic meaning refers to unity and uniqueness, is the circle. Muslim artists created geometric dimensions from the single circle. Like one of the common forms in nature, it is symbolically reflected in the signs of creation, just like the sun, which is one of the signs of divinity (universal symbol). [13] A circle is a prime example of a basic geometry, which consists of all the main dimensional geometries in traditional architecture. [14].

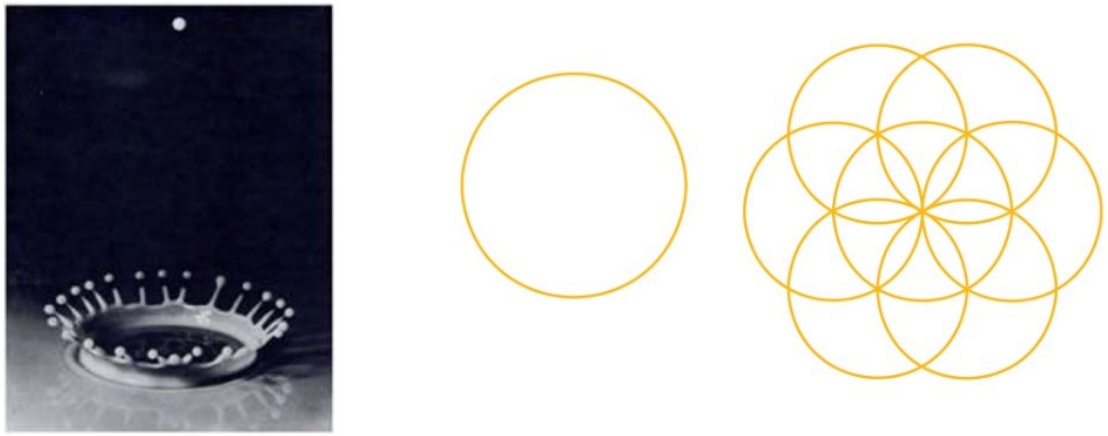


Figure 1: unity in multiplicity and multiplicity in unity, the primary circle of representation of wholeness, evolution, unity and eternity [7]

The circle of continuity is the most important form, as it consists of a circular circumference around a fixed center. Referring to the science of geometry, it becomes clear that the mother circle is the main source of all regular polyhedra. That is, the circle has the ability to produce and enclose all regular polyhedra. Triangles, squares, pentagons, hexagons, octagons, decagons and dodecagons are all produced by a circle and are placed in its heart. [6] This concept refers to the natural principle of unity in multiplicity and multiplication of the unit, which is observed in nature as the production of living organisms from the multiplication of cells.[15].

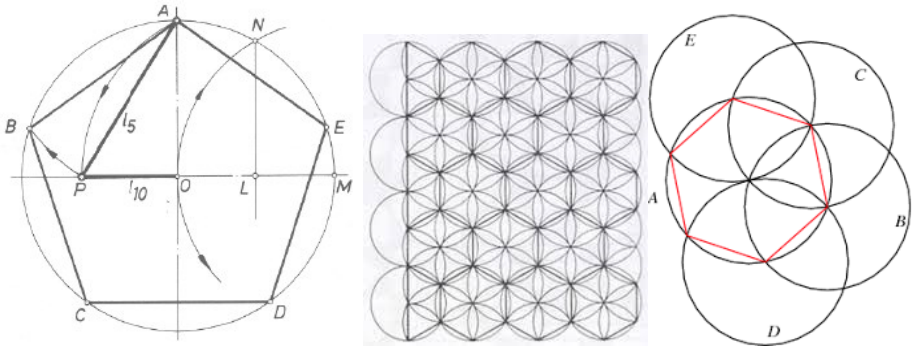


Figure 2: Unity in multiplicity and multiplicity in unity [7].

Functional properties of square and rectangle:

A square is a regular geometric shape that starts from equilateral triangles (triangles) and ends with a circle. The triangle has a completely static form that is violent on the outside and functionally limited on the inside (its corners have closed angles). [16] The square has a static and solid form that does not have the violence of the triangle and its functional limitations, and it is easier to obtain in terms of construction. Polygons from pentagons to circles have static and moving forms and are difficult to construct. [17]

As we know, the geometric shapes that cover the surface are triangle, square and hexagon, and in this order, the use of pentagon, heptagon, octagon and circle cannot be used as a module in the design of the complex plan. Because people need more security and peace in their homes from a spiritual point of view. Square form is preferable to triangle and hexagon. [6, 9].

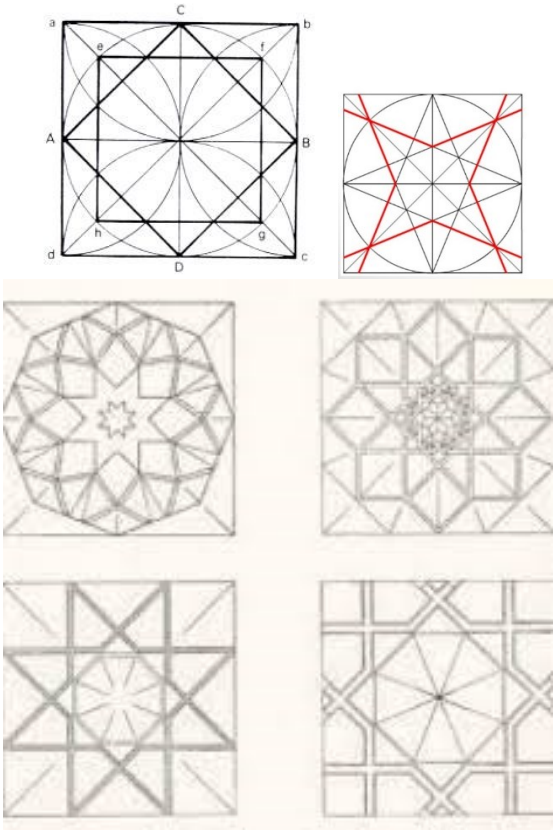


Figure 3: functional properties of the square [7]

Platonic forms:

In the Timaeus, Plato describes the way in which the divine creator made the visible world. The five

elements are attributed to the basic solids, which are called Platonic solids. "Platonic shapes" are the names given to the 5 three-dimensional shapes: quadrilateral, hexagon, octagon, dodecagon, and icosahedron (complete shapes). are formed at the time of division into spheres based on its exact shape and angle. [3, 8] In fact, these are possible regular polygons whose faces are regular and identical polygons. For the Greeks, these 5 shapes were the core pattern of physical creation. They were considered as the prototypes behind the 4 elements (earth, air, fire, and water). [18]

The need to pay attention to the role of geometry in contemporary architecture

The discussion about the position of geometry in Iranian architecture requires a wide scope, but a short mention of these basics can help to better understand the place of geometry in architecture education. Geometry and proportions are the basis of Iranian art and architecture. [12, 17] The abstract attitude of Iranians, especially after Islam, to the idea of art and the environment, is the basis of the Iranian people's understanding of the world. This geometric attitude includes a wide range of Iranian architecture from beauty and aesthetics to structures and foundations. [13]

The emphasis of Iranian architecture is on beauty. Iranians have always placed a high value on beauty for many centuries, and since the purpose of architecture was to capture the spirit and intellect, geometry became a tool in the hands of Iranian architects to create forms of plants and animals that were holy to develop. [16, 19] The science of geometry is a powerful tool in the hands of an Iranian engineer, which can be used to measure the proportions of the sky and create a balance of harmony, beauty, and order on the earth, therefore geometry is both a science and an art for an Iranian architect. [4]In other words, geometry has been part of the manifestation of the concept of beauty in Iranian architecture. In the historical monument of architecture, all sizes in their perfection, height, length, and width, and their components (including geometric patterns) are interdependent and have never been separated from geometry. [5] It is seen that there is nothing separate from Euclidean geometry. [9] The geometry of the circle and internal divisions is one of the most widely used geometries in Iranian architecture, such as the pattern of the Qaboos dome, which is based on the geometry of the circle, the definition of the octagonal geometry, which is based on the geometry of a square and its internal division. [19] Geometry has usually been very widely used in Mausoleums and Iranian architecture. Among these, it is possible to mention the hinges of the entrance porches, the formalities in the domes of mosques, naves, rooms, gardens, mosques, houses, alleys, streets, and the relationship between each of these elements, which are all based on Euclidean geometry. [20] This form, the art of geometry is the key to establishing a connection between the building and the ideas that the builder has in his mind.

With the beginning of the Islamic era, another chapter in the decoration of art and architecture of Iran began. Since the creation of human and animal images was prohibited in Islamic art, Muslim artists focused on creating abstract shapes and abstract motifs. [21] A special feeling and thought were assigned to him. Geometric motifs show unity in multiplicity and multiplicity in unity in a more obvious way. Also, the slim patterns, which have an apparently vegetable role, are so far away from nature that they show stability in change and create a special spiritual atmosphere that refers to the world of monotheism. [22].

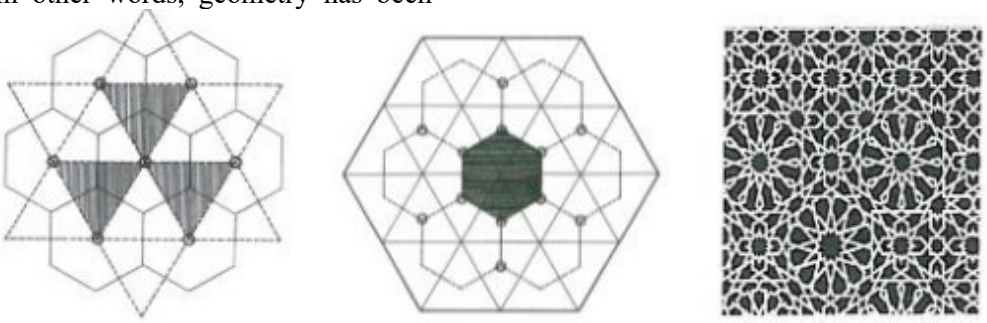


Figure 4: Using mathematics and precise geometry in Iranian-Islamic decorations [8]

The need to pay attention to the role of geometry in contemporary architecture

The architecture of the past periods, Iran has always been inspired by the use of geometry and rich and precise drawing methods, to the extent that knowledge of mathematical and drawing rules and their application has been the duty of every architect, and beyond that, engineering knowledge

with knowledge and geometrical insight. and the distinction of architects and their competition with each other has been based on this axis. [5,9] Hence, it is clear that geometry is important in Iranian architecture, and understanding how this characteristic is in contemporary architecture and matching the considered characteristics in contemporary and past architecture becomes important and necessary. [23]

Studies and experiences show that obtaining and applying the principles of geometric design in contemporary architecture, which is compatible with the conditions and facilities of contemporary design and implementation, will be effective in increasing the speed and accuracy of building construction through the correct drawing and implementation of the building. [6] On the other hand, it will help to create a logical identity in the selection and combination of shapes and volumes in architectural designs.[24]

Research Background:

In 2019, Amanpour et al., in their article entitled "Investigation of the geometric proportions of the facades of residential buildings in Tehran about visual beauty to improve urban design" compiled criteria for the design of modern residential facades based on the extraction of geometric proportions that lead to looks beautiful. [25]

Belilan and Hasanpour Lamar in 2018 in the article titled "Geometric Pattern and golden proportions, the Common Language of Architecture and Art in the Historical Village of Abyaneh, identify the geometric patterns in all the artistic designs of the historical village of Abyaneh, to the secret of how the same geometric designs are formed in wide levels of Understand these arts [26].

The results of Ali Dahar and Reza Alipour's research in an article entitled "Geometric analysis of the architecture of the Sheikh Lotfollah Mosque in Isfahan to determine the geometric relationship between the prayer hall and the entrance hall of the building" show that the dimensions of the prayer hall are proportional to the dimensions of the entrance hall and location. This space is connected with the positioning of the entrance of the building in the body of a certain square and a geometric process. [27].

Pourahmadi in an article entitled "Geometry in the Dome of the Mausoleum of Sheikh Zahid Gilani is a model for the design of the dome on the south bank of the Khazar", to find out how the designer determines the shape of the dome, among the factors influencing the shape of this dome, its hidden geometry has been explored. In this article, with the help of geometric analysis, it was clarified that in the design of the dome of this building, There are special geometric relationships, and as a result, it can be considered probable that the designer of the work has also used such geometric drawings in the design of the dome and thus a part of the logic of the creation of the work is clarified [28].

Ansari et al., in an article entitled "Research on the historical course of systems for adjusting proportions in architecture with an emphasis on practical and aesthetic considerations", the proportions used in architectural works before the third century were studied unconsciously and with regard to human aesthetics. According to them, today there are fewer proportions that can induce beauty in the eyes of the beholder, and logical numerical and geometric proportions are used [29].

Bamanian et al., in an article entitled "The use of geometry and proportions in architecture, have provided solutions in terms of aesthetics by examining the concept of geometry and proportions from different perspectives, as well as from different historical periods and numerous examples [30].

Ansari and Nejad Ebrahimi in the article "Geometry of proportions in the architecture of the Qoyunlu Turkmen period of the blue and turquoise mosque of the Islamic world" study geometry and proportions, building decorations and shapes used, materials and styles based on those motifs and Slim and geometric forms have been placed together, they have concluded that the investigated proportions, in addition to the decorations in the building, have also been of interest in its geometric structure [31].

Khwarazmi and Efhemi in their research entitled "Applied geometry in the decoration of architectural works of Iran before Islam" by examining the three historical periods of Achaemenid, Ashkan, and Sassanid have concluded that applied geometry in Achaemenid architecture with a simple repetition of the role of natural elements and Abstraction in Parthian art with the influence of Greek art, geometric patterns have become more complex, and in Sasanian art, there has been remarkable progress in geometry in terms of increasing complexity and using new divisions. [32].

In research entitled "Introduction to the Identity of Islamic Architecture in Architecture and urban planning", Noghrekar investigated the geometry and proportions in Western architecture and Iranian architecture during the pre-Islamic and post-Islamic periods and then applied it to architecture and nature [33].

In article entitled "Sacred Geometry in Nature and Iranian Architecture", Hijazi discusses the golden proportions and other proportions that contributed to the beauty of the building in terms of geometry, as well as the use of proportions in nature and its application in Iranian architecture. examines the tradition [34].

From the summary of the material presented in this section, it can be concluded that the unit of measurement of proportions can be divided into four categories of column construction, Ken and Shako, modular and pimon, which in the column construction method, proportional criteria are based on the diameter of the column and It has different proportions in different ways as mentioned, and in Ken and Shako, it is a single Ken, and the division criterion is based on squares with a diameter of one Ken, used to identify the proportions, and in the modular system, basic and multiple modules are used, and the small pimon And large is also measured based on nodes. Also, it is concluded that the Ken unit is approximately 1.5 times the size of the large pimon [35].

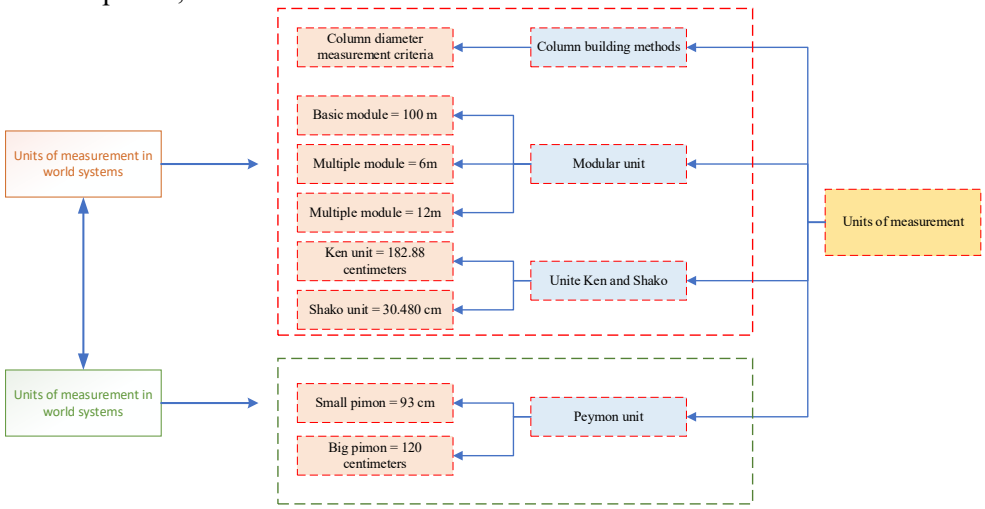


Figure 5: Diagram of measurement systems

Research Methodology:

The research method is developmental-applicative and causal-comparative in terms of method. First, a systematic review is formed based on existing geometric proportional systems, and then extracting and presenting them in terms of the conceptual framework is discussed.

Thus, in order to extract the components and variables of the research, first, the articles were identified and extracted from scientific databases, and duplicate records were removed. The articles are mentioned in the theoretical foundations of this research. Then, using the screening method, the title and abstract of the extracted articles were studied, relevant articles were selected and unrelated articles were removed. Again, re-screening and study of the introduction, conclusion of the screened articles of the previous stage selection of relevant articles, and removal of irrelevant articles were done. In the last stage, the final evaluation of the articles extracted from the previous stage was done by studying them and taking into account the goals of the project and finally the final selection of the articles. Finally, the conceptual framework was designed according to the extracted variables.

Then, according to the number of variables extracted, a questionnaire with a Likert scale is compiled and provided to space users and designers. The snowball system is used to sample designers, and the upper limit of Morgan's table, which is 384 people, is used for space users, which includes users and visitors.

The statistical population was divided into two categories of experts, architecture students, and they were asked to study the design of the monuments of the contemporary period selected in this research in terms of geometric proportions. Then, they were asked to enter their answers to the five-choice questionnaire: fully appropriate, appropriate, moderate, disproportionate, and completely disproportionate. It is necessary to explain that different images of the selected buildings were provided to them through the EPOLL system.

The results are entered into the ORIGINPRO software and analyzed with inferential and descriptive statistics using graphical and numerical methods. Finally, PN modeling is used to achieve more beautiful proportions in the creation of mausoleums. The validity of the questionnaire was measured by the differential validity of the correlation type, the value of which was r=0.881, and the reliability was calculated with Cronbach's alpha, which was equal to 0.766, which indicates the high accuracy of the data collection tool.

Study area

In this research, due to the vastness of the mausoleums, it is the Delphi system with three phases of brainstorming, limitation and selection. In the selection stage, the panel of experts is asked to rate the introduced buildings. The selected buildings are as follows.

Table 2: Introduction and explanation of the Kendall coefficient of selected mausoleums

Pictures	Description	Kendall coefficient	The name of the building
	The Mausoleum of Saeb belongs to the Pahlavi period and is located in Beheshti St., Saeb St., Isfahan, and this work was registered as one of Iran's national works on 20th of Bahman 1355 with registration number 1976. Saeb Tabrizi is one of the famous poets of the 11th century of Hijri, who is related to Shams Tabrizi, Murshid and Murad Molavi. His tombstone bears the date 1087 AH.	0.719	Mausoleum of Saeb Tabrizi
	The Mausoleum of Kamal al-Molk is a building in the city of Neyshabur, Iran, which is the burial place of Kamal al-Molk. This building is located near the Mausoleum of Atar Nishaburi in Shadiyah neighborhood. The designer of this monument is Hoshang Sihun and it was unveiled in a ceremony on April 1, 1963 with the presence of Farah Pahlavi. On the map, this building consists of two square-shaped modules that make a rectangle with a ratio of 1:2. The sides of the square appear in the facade with a semicircular arc; The volume of the building is created from the crossed arches that are placed on the square dimensions, which evoke the "quadrant vaults" that are seen a lot in the traditional architecture of Iran and were probably the source of the designer's inspiration. By creatively using the arch and twisting its general idea, the designer has achieved an apparently different result with a complex geometry. This innovative design has been implemented using a concrete shell structure.	0.771	Mausoleum of Kamal al-Mulk

	Nader Shah Mausoleum is a building in the garden complex of Naderi Museum in the city of Mashhad, which was designed and built by Hoshang Sihon in memory of Nader Shah Afshar in 1963. The building of Nader Shah Mausoleum consists of the central part, which is the burial place of Nader Shah, and two museum halls, one of which displays the weapons museum of different periods of Iran's history, and the other displays the weapons museum and artifacts related to the era of Nader Shah. This building was registered as one of the national monuments of Iran on 18 December 1975 with registration number 1174.	0.772	Mausoleum of Nader Shah
	Bu Ali Sina Mausoleum is a monument to Ibn Sina, an Iranian philosopher, scientist and physician, located in Bu Ali Sina Square in the center of Hamedan city, and this work was registered as one of Iran's national monuments on May 21, 1997 with the registration number 1869. The previous building of the Mausoleum Bu Ali Sina was built during the Qajar period. This Mausoleum was built by the order of a girl named Negar, the granddaughter of Fath Ali Shah Qajar. The preparations for the construction of the current building were made in 1943, when Mohammad Reza Shah Pahlavi personally gave 100 thousand tomans for the construction of the Mausoleum, and the National Antiquities Association tendered the plan of the Mausoleum building. Iranian engineers won the tender. The design of the mausoleum was adapted by the engineer Hoshang Sihon in the architectural style of the period and century in which Bu Ali Sina lived, based on the oldest historical Islamic building, Qaboos Dome Tower in the city of Kavus Dome.	0.801	Abu Ali Sina Mausoleum

	Ferdowsi Mausoleum is the burial place of Hakim Abolghasem Ferdowsi in Tus. This building was designed and renovated by Hoshang Sihun based on the previous design of Karim Taherzadeh Behzad, with a slight change in size and decorations. The executive architect of the building was Hossein Larzadeh, and Hossein Hajarbashi Zanjani and Taghi Darodian were in charge of the construction of this building. Ferdowsi's Mausoleum was opened in 1934. Ferdowsi Mausoleum has been built and destroyed many times. In the reports made by Iranian and foreign researchers in the last two centuries, a humble building covered with wheat fields has been seen. Finally, at the beginning of the 14th solar century and at the same time as Iran's new nationalism, efforts were resumed to build a Mausoleum worthy of Ferdowsi. The current area of the Mausoleum complex is nearly six hectares and includes the Mausoleum garden, a pool and a statue of Ferdowsi by Abolhasan Sediqi in front of it, a monument, office buildings, a library, a museum, the Mausoleum of Mahdi Akhwan the Third and the Mausoleum of Mohammad Reza Shajarian. The interior architecture of the building also includes tiles, prominent stone motifs from Shahnameh stories and stone inscriptions from Ferdowsi's poems and others.	0.728	Ferdowsi Mausoleum in Mashhad

Research findings

Descriptive statistics

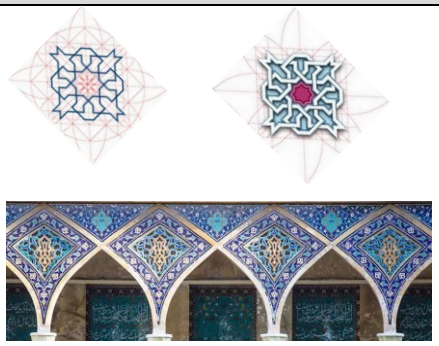
First, we study the characteristics of the studied mausoleums.

Table 3: Characteristics of the studied mausoleums

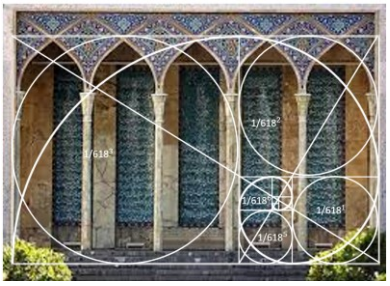
Mausoleum of Saeb Tabrizi

Golden spiral

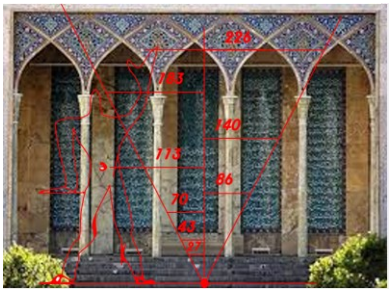
golden ratio and Golden rectangle



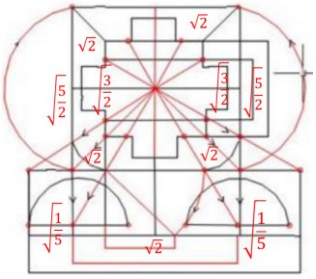
Golden Triangle



Circles 1 to 1/618



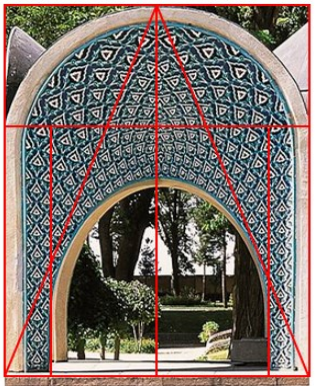
Le Corbusier's Modulor



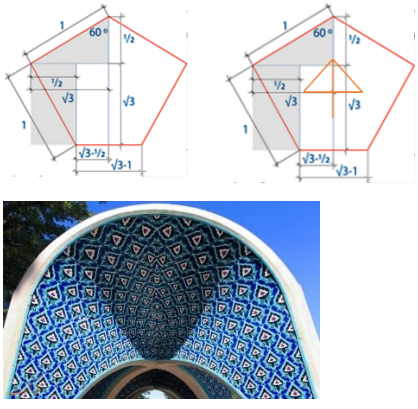
Ken and Shako

Mausoleum of Kamal al-Mulk

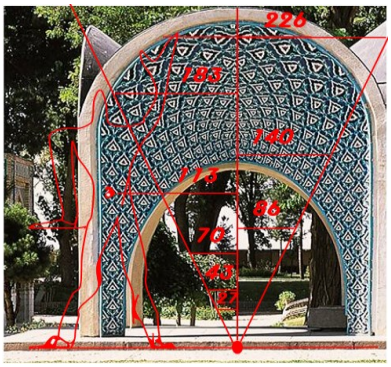
Golden spiral

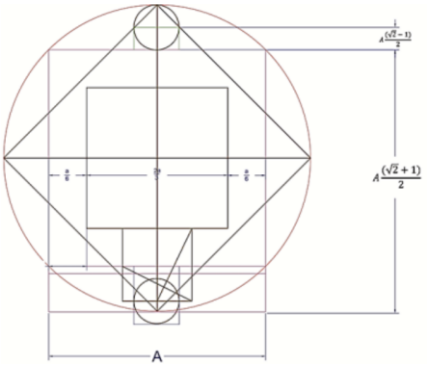


golden ratio and Golden rectangle



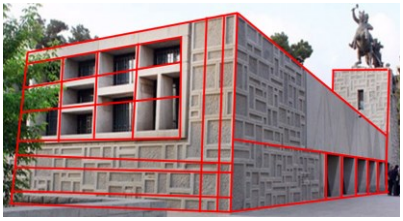
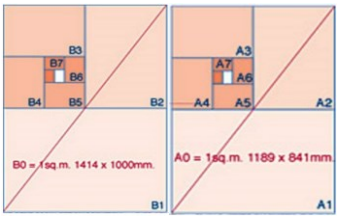
Golden Triangle



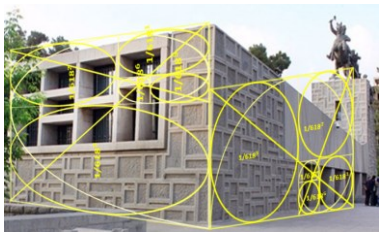
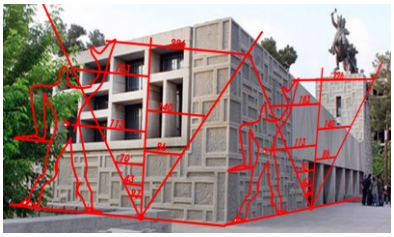
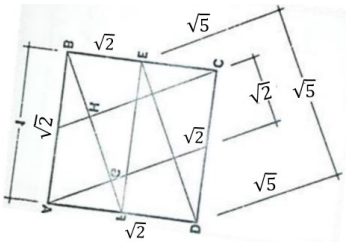


Circles 1 to 1/618 | Le Corbusier's Modulor | Ken and Shako

Mausoleum of Nader Shah

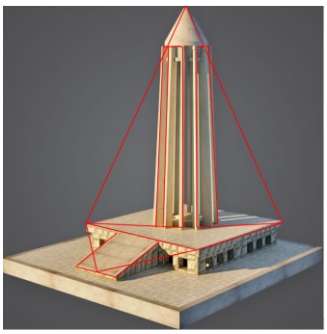




Golden spiral | golden ratio and Golden rectangle | Golden Triangle

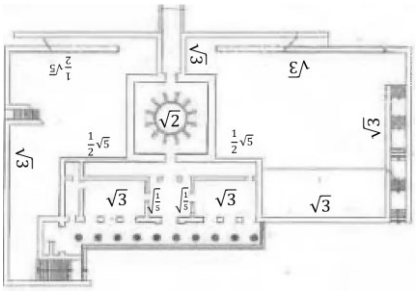
Circles 1 to 1/618 | Le Corbusier's Modulor | Ken and Shako

Abu Ali Sina Mausoleum

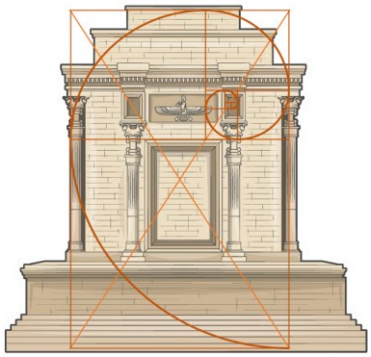

Golden spiral | golden ratio and Golden rectangle | Golden Triangle



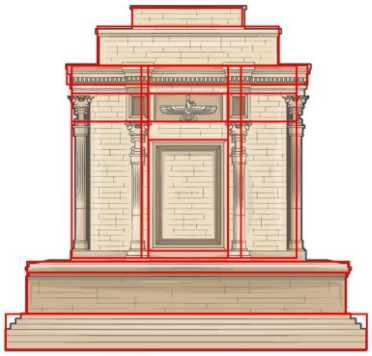


Circles 1 to 1/618 | Le Corbusier's Modulor | Ken and Shako

Ferdowsi Mausoleum of Mashhad

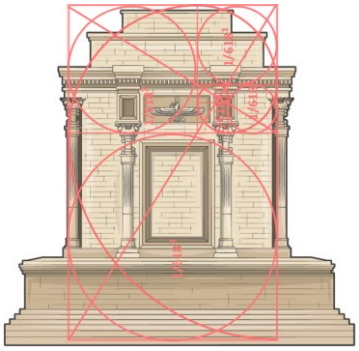


Golden spiral

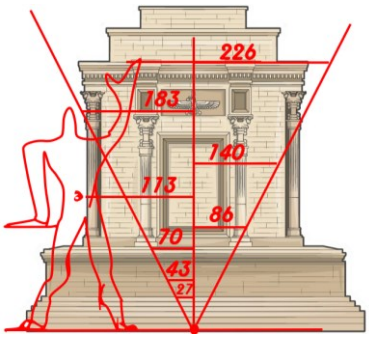


golden ratio and Golden rectangle

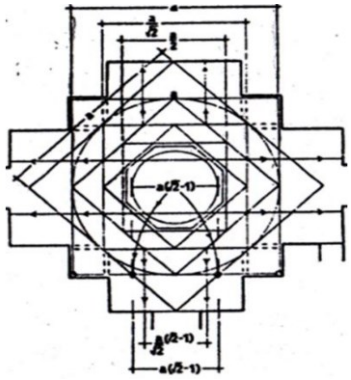
Golden Triangle



Circles 1 to 1/618



Le Corbusier's Modulor



Ken and Shako

Findings and results from proportional analysis
Ken and Shako's analysis

In the plan of Saeb Tabrizi's mausoleum, the base of √2, i.e. equilateral triangle and its derivatives like √(3/2), in the height of the triangle, at the base, a square that is divided into halves is used. In this rule, the ratio of √(1/5) to √(5/2) is used. In the mausoleum of Kamal al-Mulk, the width of the facade is a productive unit, the length of the outer right corner is half of the sum of the diameter and the side of a square based on the length of the facade or A:{(√2+1)/2} . This right corner is formed by making a square with side A and a second square with the same center that is 45 degrees. The distance from the center of the base of the first square to the opposite corner of the rotated square (xy) gives the required dimension. The crescent part above the facade is divided into eight parts. In the mausoleum of Nadershah, rules 1 and 6, i.e. square and half square, have been used throughout the facade. √2 and √5 are used in the base part.

In the mausoleum of Bo Ali Sina, the generating unit is the square side of the dome of house A. The diameters of the semi-square are drawn, and from their intersection, a smaller square is obtained in the center. The length of the side of the smaller square is equal to a√(1/5), thus the diameter of the semi-square is divided into three parts in the ratio of 1/√5:1/√5:1/2 √5. It was very easy for the builder to use the shortest part to determine the width of the arches radially. The width of the other arches is equal. By continuing it, the building arch reaches the width of the eastern and western arches. The north and south arches are a little deeper and do not seem to have been obtained by this method.

In the Ferdowsi Mausoleum of Mashhad, the length of the facade is five times the side of the main square (√2-1). The base of concentric squares with the growth law of √2-1 creates regularizing lines that rely on an eight-pointed star, and its successive sides are related to each other with a ratio of √2-1.

The Golden Spiral and Circles 1 to 1/618

In the examination of following or not following the proportions of the golden spiral, it is concluded that the general view of the selected mausoleums and their components follow the proportions of the

golden spiral. The whole view follows the ratio of the square surrounded by circles following the ratio of 1 to 1/618.

Golden ratio and Le Corbusier's Modulor analysis

The general design of the facade does not follow the proportions of the Platonic rectangle, and the analysis of the components of the facade based on the proportions of the Platonic rectangle also shows the following of the proportions of the Platonic rectangle. In the analysis of radical ratios, the outline of the form follows √2, √3, and √5 and their derivatives, and in the components of the form, only some forms of the ratio √2، √2-1،1/2 √51 ،/√5 follow. Also, the height of the entire facade follows Le Corbusier's Modulor system, but the height of any of the facade's components does not follow Le Corbusier's Modulor system. In examining the golden ratio, some elements of the facade follow this ratio, and the rest of the elements do not follow it.

Analysis of the Golden Triangle

In the mausoleum of Bu Ali, it is made of equilateral triangles drawn from the center of the square. These triangles are made by enclosing a circle inside a large square and dividing it into twelve parts. The radii are drawn from the points and extended to the sides of the square. Four are equilateral triangles whose base is equal to a√3. If the bases of the opposite triangles are connected with lines, the width of the intersecting arcs in the dome of the house is obtained. The inner square is the dimensions of the dome. The rest of the dimensions of the building are all proportional to the equilateral triangle and can be found by extending the sides of the triangle and the sides of the square as shown in the geometric figure. In the mausoleum of Kamal al-Mulk, the base triangles have sides equal to the side of the square or a. The thickness of the north and south walls is equal to the east wall. The sides of the outer square extend eastward to intersect the continuation of the large triangle (its sides = a) and form a larger triangle. In the mausoleum of Ferdowsi, it consists of equilateral triangles with lengths of a√3. In this way, the four large dimensions of the building follow the rule of 3a, a, a√3, √a3, and 1/3 as members of the geometric sequence.

In the mausoleum of Nader Shah, facade buildings are formed by connecting the bases of equilateral triangles. If we consider the facade as the base, the height of the triangle that is built on this base will match. In the mausoleum of Saeb Tabrizi, rules 4, 3, and 2 are used for equilateral square triangles in the plan, and rule 6, which means half a square, is used in the facade.

Inferential statistics

In the next stage of examining the proportions in the selected mausoleums, a questionnaire will be compiled by experts to check the effect of these variables on the geometric proportions of the mausoleums.

According to the results obtained from the descriptive statistics, 256 people (66.6%) of the sample size are men and 128 people (33.3%) are women in the age group of 20-30, 30-40, 40-50, 50-60. have been years The working method is such that a question is formulated and provided to spatial users for the effect of each geometrical proportion. Each question has an answer between 1 and 5 (very little to very much). The sum of the scores of indicators of a component means the score given by each person to the desired quality, so the score that can be obtained for each quality is between 1 and 5. The results of descriptive statistics and data distribution show that the highest frequency is related to radical ratios in components with a value of 1884 for designers and 1783 for users, and in the general plan, it is related to the Golden Triangle with a value of 1796 for designers and 1700 for users, and the lowest Faroni is related to Ken and Shako in flower design and components, which is 1101 for designers and 840 for space users.

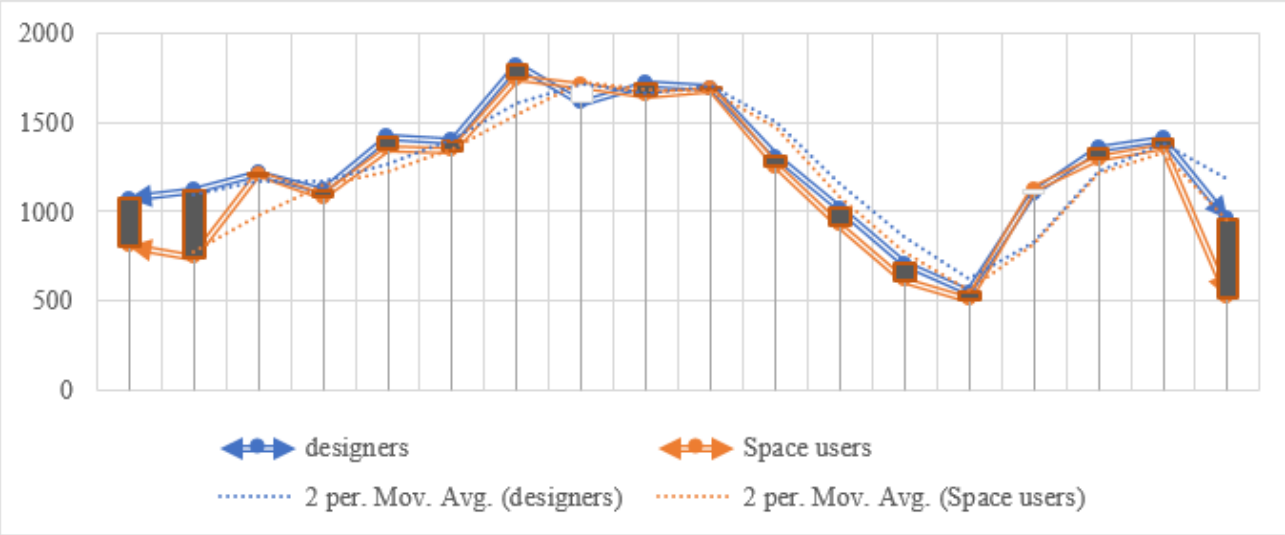


Figure 6: Frequency diagram of the use of various proportions in selected mausoleums

Inferential statistics:

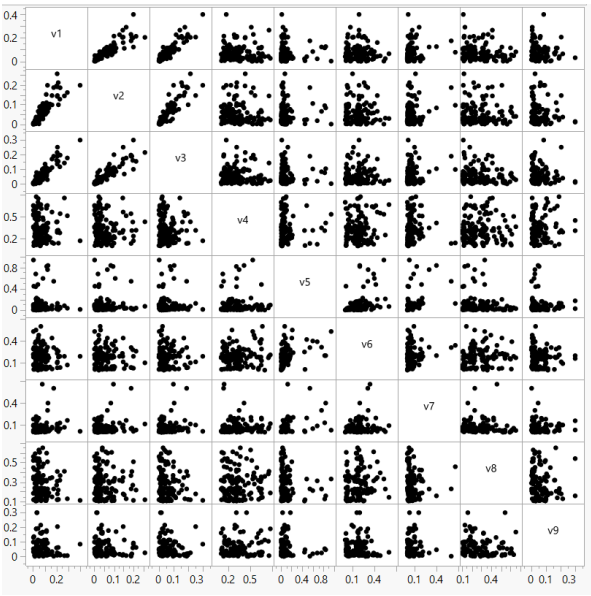


Figure 7: Diagram of the correlation matrix of the components

At this stage, after extracting various geometric proportions, the selected mausoleums are evaluated. The results show that the greatest impact in the design of these buildings is the use of radical ratios with a value of (1.000) and the least related to Ken and Shako for components with a value of (0.163) for designers and (0.152) for users. In the section of general design, using the Platonic rectangle with a value of (0.902) for designers and (0.846) for spatial users has the greatest contribution in the formation of contemporary mausoleum designs.

Table 4: Multivariate regression of geometric proportions for two groups of space users and designers

Type of geometric proportions		Designers				Space users			
		The coefficient of determination	F	β	t	The coefficient of determination	F	β	t
Ken and Shako	Components	0.163	219/614	0.781	453/67	0.152	342/411	0.741	571/44
	Outline	0.201	149/823	0.384	330/72	0.120	446/444	0.429	365/31
Modular Lucor	Components	0.612	384/152	0.862	825/64	0.503	752/985	0.623	255/31
Bozier	Outline	0.691	923/598	0.619	364/67	0.546	223/211	0.685	479/58
golden ratio	Components	0.593	259/547	0.617	960/46	0.681	773/225	0.621	982/21
	Outline	0.714	323/944	0.492	646/44	0.509	681/653	0.652	134/11
Radical ratio	Components	1.000	526/145	0.861	424/49	1.000	654/724	0.612	425/24
	Outline	0.412	257/054	0.668	146/47	0.769	621/741	0.381	132/23
Platonic	Components	0.729	543/424	0.282	233/67	0.814	325/512	0.484	121/48
rectangle	Outline	0.902	243/532	0.482	916/57	0.846	748/276	0.464	963/47
Circles 1 to	Components	0.428	323/501	0.419	223/52	0.403	125/302	0.372	564/43
1/618	Outline	0.371	126/743	0.428	250/76	0.243	034/519	0.872	448/49
Golden spiral	Components	0.695	136/822	0.436	290/53	0.895	125/521	0.685	214/15
	Outline	0.721	267/529	0.682	256/93	0.978	258/149	0.597	216/22
Golden	Components	0.519	414/623	0.439	519/77	0.462	214/315	0.436	552/22
Triangle	Outline	0.264	213/741	0.512	328/53	0.331	371/458	0.852	354/18
Rand factor of	Components	0.833	543/621	0.462	353/86	0.745	695/325	0.665	341/32
base modulus	Outline	0.387	993/921	0.398	326/57	0.254	937/621	0.213	571/44

In the stage, for the degree of intensity of each selected mausoleum, geometric proportions are used in the form of a combination of a comparative comparison chart, which shows that users and designers are familiar with the application of geometric proportions, but the group of spatial users with the basic Rand coefficients module and Ken and Shako don't know each other, that's why these cases have a lower factor share.

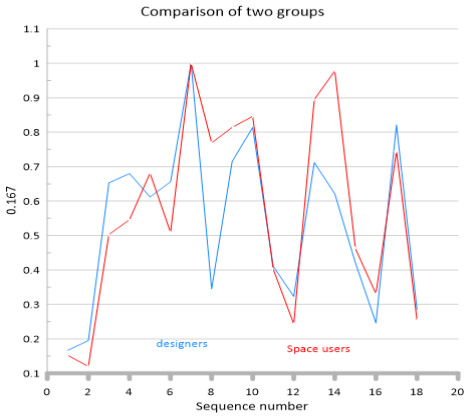


Figure 8: chart comparing the coefficients of determining the use of geometry in two groups of designers and space users

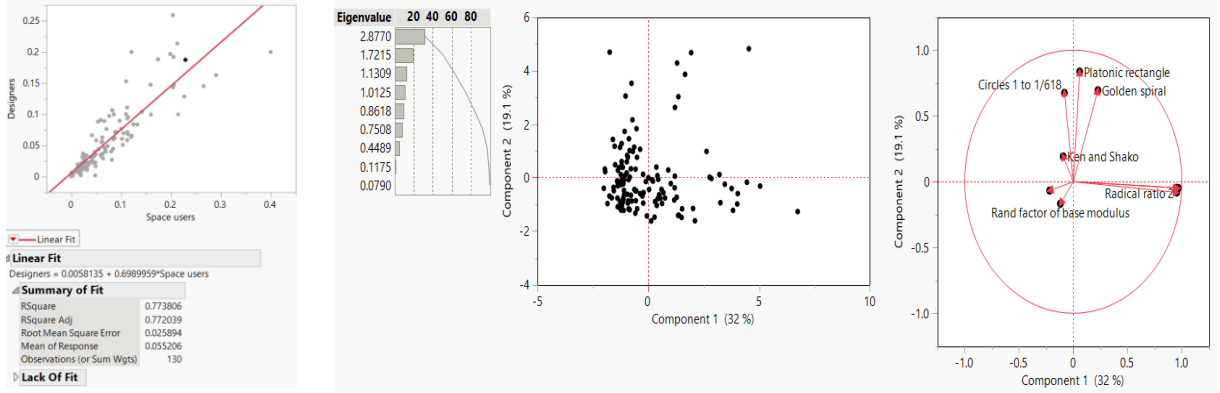
In the next step, PN modeling is used to improve and increase the contribution of each proportion in creating beauty through design. In this step, the responses of users and designers are collected together, and the results are extracted from the numerical average between these two groups and entered into the modeling. The results indicate that if proportions are used together as follows, their effectiveness can be improved to a high extent in order to achieve beauty;

Radical coefficients, Golden Triangle, golden ratio

Base modulus coefficient, Ken and Shako Circles 1 to 618/1, Platonic rectangle, golden curve

Also, at the end, a graphic correlation is taken between the responses of designers and spatial users. The results show that the answers are explained by each other with a value of 0.773.

Table 5: PN modeling and graphic correlation of the components of geometric proportions

Graphic correlation	PN modeling
	

Discuss

The science of geometry has long attracted the attention of thinkers and many researches have been conducted on how to use it in buildings and how it is formed in the designer's mind during the design process. However, the relationship between the designer, the audience, and the work as an undeniable interactive relationship in architecture has not been investigated as a whole and this doubles the importance of this research. One of the goals of this research is to present a geometric pattern to achieve the desired architecture in the matter of design and to achieve this, the qualities of the seer of subjectivity in interactive art and the features of geometry in works of art have been studied with the method of elemental analysis. The most important goal of the research is to identify the relationship between the science of geometry and the way it is formed in the shape of buildings, how it affects the mentality of the designer and its representation in the matter of design, as well as the process of the audience's perception and reading of the science of geometry. Examining this relationship and finding the missing links in this matter will help us to achieve the desired architecture. To achieve this goal, the meaning of geometry in Iranian architectural works will be investigated. The basis of the selection of the works is the contemporary mausoleum buildings, where the two themes of tradition and modernity are included in the physical plan of the building. The difference between this research and previous research is that this study, from an architectural point of view, deals with the analysis and recognition of geometric proportions and practical geometry in selected buildings.

In this research, two groups of space users and designers measure the geometrical proportions, on this basis, no research has been done with this method, and the explanation of the geometry in the formation of mausoleums in the components and general design has been mentioned. Based on the descriptive statistics and the support of the moving average from the data distribution, it can be concluded that the tool was able to accurately measure, and the results of the descriptive and inferential statistics support each other, and the results show that radical ratios such as 5, 2, 3 has caused brevity in the design or form of the built building and has made it attractive. This research showed that in the design of mausoleums in the contemporary era, attention is paid to the geometry in details more than the general plan, and the focus is on the application of proportions in the components of the mausoleums. Also, Tasbat Ken and Shako have very little indication of general and detailed plans, which is due to the distance of these types of proportions from our native culture. In PN modeling, it was found that the application of proportions together can lead to the improvement of their effect in creating beauty or desirable design.

Conclusion

The issue of using proportions has been discussed since the beginning of human creation, this is related to the environment surrounding human life and has been the focus of scientists and artists for a long time. In human life, proportions mean creating a visual order that emerges between the parts of a

whole. Most scientists, architects, and artists always followed the system of setting certain proportions in the execution of their works. The system of setting proportions creates a set of visual constant ratios between the parts of a building and also between the parts and the whole. The law of golden proportions in the third century B.C. was discovered by Euclid, a prominent Greek philosopher and mathematician. After some time, the Greeks realized the dominant role played by the proportions of the human body, believing that both man and his shrines could belong to a superior order of the world. These proportions are reflected in the buildings of their places of worship. During the Renaissance, architects also took advantage of this rule, and Le Corbusier adjusted his modular system based on the golden ratio, and its use continues to this day in architecture. Theological ratio, the golden ratio, and the divine ratio are different names applied to the golden ratio. The term theological ratio is attributed to the ancient Egyptians and divine ratio to the Italian architect Vitruvius of the 2nd century AD, but the term golden ratio, which is more common today, has been used since the end of the 19th century. First, to understand the types of proportions as well as the geometric proportions, the ratio, and proportion are checked In contemporary buildings, geometric proportions of the square and its derivatives, such as equilateral, its derivatives such as side and height, half square, and root of five rectangles are used. The common feature of these mausoleums is the use of geometrical shapes such as triangles, squares, and different regular polygons, spirals, and circles as diversity in unity. According to the geometric drawings of the plan, it can be said that their architects have used a combination of the rule of 5 half-squares, i.e. √5 and its derivatives such as 1/√5, square √2, and equilateral triangles and their derivatives √3. The variables extracted from geometric proportions are divided into six categories: Ken and Shako, golden spiral, circle 1:1/618, golden ratio, modular Le Corbusier, and golden triangle.

According to the regression results, in the architecture of the selected mausoleums, the golden ratio had the greatest effect and Ken and Shako had the least effect on the geometric proportions. Through the geometrical analysis of these mausoleums, it can be shown that various ratios such as the golden ratio have been widely used in Iranian architecture, such as the design of plans, sections, architectural and geometric patterns, and structural and mechanical features.

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