

Received 2017/02/06
Accepted 2017/08/23

Persian translation of this paper entitled:

گونه‌شناسی بافت نمای شهری (با رویکرد شکلی)
(نمونه موردی میدان امام خمینی(ره) تهران)
is also published in this issue of journal.

The Typology of Urban Façade Texture (in an approach to shape scrutiny) (Case study of Imam Khomeini Square in Tehran)

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Abstract

In studying the architectural evolutions, it is necessary to scrutinize the climatic, shape and historic typologies. Reviewing these studies clarifies the researchers' view in using the typology as a type methodology in designing different architectural properties such as the plan, mass, form, and space. For instance, Olgy reviewed and categorized architecture in terms of architectural formation due to climatic features and Durand and Krier focused on the geometric aspects of the plans. Therefore, this paper tries to offer a typology of facades as a significant aspect of architectural design since the absence of defining a proper process in façade design has led to the development of an unpleasant cityscape and inconsistent individualistic façade design all over the city.

Therefore, this paper queries the geometric and typological features in the facades of valuable buildings (traditional buildings) during different periods. In this regard, this research is conducted assuming that the correct identification and recognition of façade typology and its re-establishment in the contemporary works can hinder insipidity and chaos in cityscape while preserving the historical-cultural authenticity of the facades. Thereafter, the research is continued by drawing the basic shapes (square, triangle, and circle) according to Durand's and Krier's - by whom these shapes were introduced as the basic shapes in the typology of shapes – viewpoints as well as applying changes to the axes, vertices, and sides of these shapes in the opinion of Durand's and Krier's transformation principles in shapes in order to find the transformation trajectory in these shapes. Hence, the building facades around Imam Khomeini Square - which is a significant urban, social, political, cultural, and historical place- in Tehran city are scrutinized by library research (books and articles) and in analytical –comparative research method by studying the facades (pictures and illustrations) using 9 statistical populations from Qajar, Pahlavi I, Pahlavi II and the contemporary era (two slides from each of the four sides of the square on average). Eventually, it was concluded that the most of the geometric patterns used in the facades of the surrounding monuments during Qajar period were formed by combination or application of simple shapes such as circles and squares based on the center of the circle or in the process of repetition in terms of geometry, ornaments, and apertures. These terms during Pahlavi I period have appeared in form of triangular shapes and acute sections in a variety of combinations with a circle and a square. As for the Pahlavi II period, the influence of the principles of Western architecture led into the use of simplicity and maximum prevention in decorations in various constructions of different functions. As a result, the geometric patterns used in this period were mostly squares and the products from the square rotation in angles.

Keywords

Historical typology of the facade, basic shapes in façade, evolution of shape in facades, urban facade, Imam Khomeini Square in Tehran.

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Introduction

During the eighteenth and nineteenth centuries, flourishing of various sciences in Western Europe, especially in France and England, led to great advances (Bernal, 2001: 385). At that time, Durand, who was practicing the theoretical foundations of architectural science, and other scientists such as Laplace¹ and Monge² were the most prominent professors at the Polytechnic University of Paris (Madrazo, 1194: 14). since the theoretical debates in architecture were most affected by the science of biology, two theories of the independent formation of species (Fixism) and the gradual evolution of the traits of species (Transformisme) in science influenced architecture and the study of architectural history in particular (Sahabi, 1996:4). Focusing on the relationship between theories and the historical origins of the beings, Durand offered a form of typology to classify various buildings according to their plan and drawings (Wojtowicz, Jery: 1986). Therefore, he introduced the basic shapes (square, rectangle, and circle) and their combinations. In his drawings, he defined the major and minor axes of these shapes and described the sides as the axes and completed it by drawing of the rest of the elements including the columns and windows (Memarian, 2012). Subsequently, Krier who was considered a neo-modernist emphasized on the return to the architectural history and studied and criticized architectural works in three scales of urban, architectural and interior design (Krier, 1984). He researched on the origins of these features in the urban scale by comparing urban and architectural elements; square and street and rooms and corridors. He presented these studies as the common elements of architecture and urbanism in two different scales (Memarian, 2012). In the first in researching the process fo shape, he introduced the basic elements as the square, triangle and circle, and scrutinized them by the six principles of transformation in three aspects of function, structure, and form (*Ibid*). It is believed that identifying the trajectory of these changes and patterns from the past to the present, as well as defining a fundamental and logical approach in facade design can

lead to understanding of the origins of transformation and avoid the chaos caused by individualism in façade design.

Therefore, this paper studies the evolution of the typology of urban facade texture in Imam Khomeini Square (Toopkhaneh Square) in Tehran in the four main direction. Here, the telegraph and telephone building (current telecommunications building) on the south side of the square, Baldieh building (former municipality) on the north side of the square, Shahi Bank (Current Tejarat Bank) on the east side of the square and the traffic office (current the Imam Khomeini metro station) on the west of the square are studied as valuable in formation of this urban space in the following headings: 1. Research background 2. Description and recognition of shape approach 3. Identification of the basic shapes in architecture 4. Categorization of shape transformation in the basic shapes (as claimed by Krier) 5. Transformation of the basic shapes (as claimed by Durand) 6. Categorization of the building facades surrounding Toopkhaneh Square according to their location and construction time 7. Adaptation of the derived patterns to the categorized facades 8. The evolution process of geometric patterns 9. Achieving the geometric transformation pattern in façade design.

Research background

Studying of type and typology are among global subjects which are addressed by architects and other scholars in the historical script since two thousand years ago and it has been known for over 250 years specifically in the field of science. In his the then books on architecture, Vitruvius has categorized various types of Greek buildings, including houses, temples and public buildings (about 2000 years ago). For instance, residential buildings are categorized into houses with courtyards and house without courtyards. As for the temples, they are classified into various types based on the number of outer pillars and the quadruple classical systems. Following that, the scientific categorization of the Swedish Carl Linné in botanical sciences led other scientists to take action and pursue

this trend in architecture from the late eighteenth century (Memarian and Tabarsa, 2013). De Quincy (De Quincy, 1844), who published The Historical Dictionary of Architecture in 1844 discusses the type and model. He describes type as a sketch or a scheme that is able to influence the artist's mind, while a model is an imitable object or idea (De Quincy, 1844). Also, many other researchers, such as Aldo Rossi, Argan and Iimonito, have discussed this subject as well. In the 1990s, the subject of typology was discussed at the Harvard, MIT and Birmingham universities and the use of typology in architectural knowledge continued seriously up to the early twentieth century. Sidney Addy used the typography in his book The Evolution of the English House and Matthews used it in his book of English house. In this regard, the idea of classifying buildings based on common features started in Iran for about three decades, among which one can refer to the typology of housing in Kandovan village (Homayoun, 2007).

The type is also a key concept in architecture and urbanization and has been studied by many authors (Rapaport, 1990; Moudon, 1994; Radberg, 1996). A type as a concept refers to a form, a class or a group of people or a collection of objects that are common in distinct characteristics that distinguish them among other people or groups of objects (Rapaport, 1990: 48). In fact, according to Rappaport, "typology is an attempt to put a set of complex objects into a systematic collection in order to achieve more generality in recognition and planning" (Zakerhaghghi, Majedi & Habib, 2010).

Description and recognition of shape approach

According to the art history, a work of art is divided into forms, figures, shapes, and contents (Memarian, 2012: 57). The important point in the process of applying the shape in architecture is relating it to other elements, structures or functions. Since the eighteenth century, graphic geometry was used to transform geometry into the reality and analyze it in different building facades. This approach made architecture as

a process of combining or processing shapes. Durand (1795) who coincided with Buffon's historical-evolutionary theory in his teaching of architecture, benefitted from the theory of gradual change. He introduced it in the classification of plans and roofs of buildings from simple to complex; because unlike technical sciences, the product of shape is derived from a general process and a shape is a tool for realization in art studies especially architecture.

Durand focused on the history of architecture by referring to the style and disregarding of building location and time period, so that time and location borders were ignored in his shape analysis and understanding. For instance, he simplified the complex Saint Peter Cathedral into rectangular (Basilica) and circular (the square) shapes in one of his drawings and presented his proposed design as a combination of a rectangular square and a simple basilica-shaped space (Durand, 1800). In the light of this, Krier interpreted the space types such as the square, the street, and building plans into simple shapes. He then achieved 24 states of shape by applying his six principles of transformation (i.e. transformation, overlying, integration, addition, sector and changing the angle) in both conditions of (ordered and disordered) and (opened and closed). This approach was considered a technique in recognition of geometric patterns designed in building façade, mass, and form. It follows a referable and accepted geometric procedure in the science of geometry and leads to a full understanding of elements used in the building façade. Recognition of these elements helps us understand the formation and transformation of shapes. In this study, by applying the Krier's six principles on basic shapes and regarding their geometric features (vertices, sides, diameters, and center), the quadruple process of breaking, repetition, angle and combination were achieved. These processes have been analyzed as transformation principles in shape and they are studied in the facade of Imam Khomeini Square.

Identification of the basic shapes in architecture

The architecture science is continuously derived from a geometric process in which the design lines

are organized in a mental process by the designer. Therefore, application of geometric patterns is very significant in designing the plan as the building outlay, in the façade as the building appearance, and in the mass as the building form. Therefore, identifying the basic shapes and the way in which they are geometrically combined does not go far beyond the expectation of recognizing the past used patterns. In this regard, the foundations of the works of Durand and Krier was codified on the basis of building classification according to their outlay. Durand believed in simplifying the existing realities to geometric shapes and categorizing them in different groups (Memarian, 2012: 55). In categorizing the elements, composite components, and final products, Durand used the shapes that were common in features and in having basic shapes such as squares, rectangles, and circles. In this way, he derived new combinations based on common geometric properties such as the axis of symmetry. Krier also took the first action in identifying the shape formation process was by simplifying spatial types such as square, street, and building plans into basic shapes (Memarian, 2012: 73). In other words, the forms were simplified according to Gestalt in order to better understand the environment.

Categorization of shape transformation in the basic shapes

The transformations of basic shapes as the geometry of the building was described to the inseparable connection of function, structure and form by Krier after the motto of modern architects that asserted "forms follows function". He presented the changes of basic shapes and the process of transforming the basic elements into spatial forms and shapes in six categories (the change of the angle, sector, addition, merging, overlaying, and transformation), regardless of the geometric features of the basic shapes. On the other hand, Durand believed that the shapes can be combined based on their major and minor axes from simple to complex. He also believed that the shapes can be combined by repetition of their axes in different directions, repetition of square shapes or their mirror

reflecting (Wojtowicz. Jery, 1986). Since Krier believed transformation occur by changing a member of a basic shape, such as angular fillet or deflection, it seems less convincing as compared to Durand's work, in which the shapes were repeated or integrated on the basis of one or two geometric axes and expanded from simple to complicated (Memarian, 2012: 75). Therefore, the possible and acceptable geometric transformations that are formed by using the geometric axis of the basic shapes will be discussed in this study.

Research method and the statistical population

In order to investigate the shapes of the buildings surrounding Imam Khomeini Square (Toopkhaneh Square) in Tehran, a three-stage process was carried out: 1. Identification of the basic shapes, their transformations, and their geometric derivatives. 2. Identification of transformations in Imam Khomeini Square (Toopkhane Square) in Tehran in the four main directions from Qajar to the contemporary era. 3- Adaptation of geometric patterns to the achieved facades and identifying the geometric transformation process. This research is conducted by library research (books and articles) and in analytical –comparative research method by studying the facades (pictures and illustrations) using 9 statistical populations from Qajar, Pahlavi I, Pahlavi II and the contemporary era (two slides from each of the four sides of the square on average). The data are categorized based on the construction time and location of the facades in order to better understand and percept the square space from Qajar period to the contemporary era.

Transformation of the basic shapes

Transformation of the basic shapes by Krier's categorization can be studied via reviewing the basic shapes and their combination according to the main axes, sides, and vertices. The applied transformations are classified into four general categories: deflection, the change of the angle, repetition, and composition. The purpose of this categorization is to achieve a holistic geometric framework that can encircle all

possible geometric transformations of the basic shapes for further identification of forms and geometric combinations in plan, facade, mass, and form of the constructions.

Deflection process

This process occurs separately, dependent on the geometric characteristics of every basic shape. In rectangles, the deflection process is performed on the diameters, axes or it is performed by the combination of both actions. In triangles, this process is carried out according to the center and in circles, the deflection process is performed based on diameters, radii, and chords.

Repetition process

This process is carried out by multiplying a section without combining it with other sections. In this process, rectangular and triangular shapes are repeated on the center, vertices, and sides, and circular shapes are repeated around the center and the chords. A combination of the obtained sections can be observed in the façade ornaments.

Angle Process

In this process, the angles of the basic shapes are changed and the resulting sections are considered as the derivative of the basic shapes, which can be used in the general form of facades, ornaments, and geometry of apertures. The shapes derived from changing the angles of a square are the rhombus, the parallelogram, the right trapezoid, the trapezoid, and the rectangle. The shapes derived from changing the angles of the equilateral are the right triangle 1 (1. isometric 2. axonometric) and equilateral triangle. The derived shape from changing the angle of the circle is the ellipse (Fig. 1).

Combination process

In contrast to the three previous processes in which the sections were separately involved in the process, in this process the sections are combined two-by-two according to their four common geometric factors: the center, the vertices, the sides, and the axis. Here, the combination process is divided into the basic sections, the derivatives, and the extensions. In the column of the basic sections, the basic shapes are mentioned based on the geometric factors. In the column of derivatives,

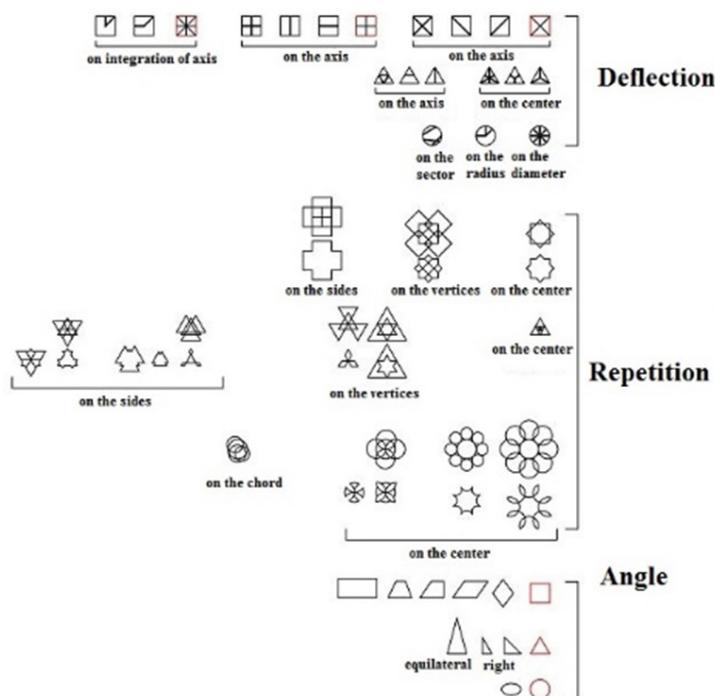


Fig. 1. Geometric transformation (deflection, repetition and change of the angle) in the basic shapes. Source: authors.

the possible geometric combinations are mentioned in two rows of the primary and secondary derivatives (the row of secondary derivatives is in fact obtained from the combinations of primary derivatives. when possible, further sections are inserted into the column section expansion (Fig. 2, 3, 4).

This stage of the research was aimed at achieving the complex shapes by using the basic shapes and their geometric properties. In the following, the products of these combinations are identified and reread in the significant elements of the facades such as the overall façade frame, apertures, and ornaments. These obtained sections are used as a geometric reference for the geometric patterns used in the facade, the general form, the geometry of the apertures, and even the ornaments. Finally, the geometric principles in façade design were adapted to the achieved geometric patterns in order to perceive the geometric evolution during the mentioned periods.

Categorization of the building facades surrounding Toopkhaneh Square according to their location and construction time

Mashgh Square (Imam Khomeini Square) in Tehran was built in 1867 during Nasereddin Shah Qajar's reign, by an order of Mirza Taghi Khan Amir Kabir in about ten years. After its formation, the surrounding uniform regular buildings around this place were destroyed and Shahi bank was constructed on the east side of the square. Thereafter, Baladieh building (which literally means municipality) was built on the north side of the square, and eventually the Wireless communication office was added on the south side of the square which was neighbored with the Police office after a while. Finally, the traffic office was built on the southwest side and the new Bank of Commerce was constructed following the destroying of Shahi Bank. Subsequent to these proceedings, the Wireless communication office was replaced by the post, telegraph and telephone office. This square is one of the first places in Tehran which was first stone paved - and later surfaced with asphalt. Toopkhaneh Square has long been the center of traffic in Tehran,

as well as a place for gathering storms of protests. During the constitutional period, this square was filled with crowds of protesters due to being close to the Arg-e Saltanati (the royal citadel) and Baharestan Square ([http2](http://www.google.com)).

Having identified and collected the data from the facades in 9 statistical population (9 buildings), the buildings were categorized based on their time of construction and location for further understanding of the square space from Qajar period to the contemporary era. These 9 buildings include Baldieh, Post and Telegraph, Telecommunication building, Shahi Bank, Bank of Commerce (current Tejarat Bank), Police office, Road Administration, Museum of Industry and Imam Khomeini Metro Station buildings. In the following table, the vertical comparison of the facades leads to understanding of the historical transformation of the square in the mentioned period. In addition, the horizontal comparison of buildings reveal the general common shapes in the building form and elements used in ornaments and apertures.

The evolution of the building facades surrounding Mashgh Square in the four main directions (Fig. 5):

Adaptation of the derived patterns to the categorized facades

In order to adapt the geometric patterns to the facades of the categorized buildings (table above) according to the four main directions, a simulation of the overall forms, apertures, and ornaments was conducted on the square sides (north, south, east, and west) during the mentioned course of time. In the tables below, the facades on every side were simulated according to their location and construction time on the left and according to their simulated geometry and their transformations, geometric patterns of the basic shapes and their derivatives on the right.

The geometric transformations created in the basic shapes was clarified based on the quadruple transformation principles of deflection (sector), repetition, composition, repetition, and angle by the help of color according to the guidance given below

derivatives	Basic shapes	derivatives	Basic shapes	Geometric factors
				on the center
				on the vertices
				on the sides
				on the axes

Fig. 2. Geometric transformation (combination of the circle and the square) in the basic shapes. Source: authors.

Triangle and Square				
derivatives	basic sections	derivatives	basic sections	Geometric factors
square		triangle		
square		triangle		
square		triangle		
square		triangle		
square		triangle		

Fig. 3. Geometric transformation (combination of the triangle and the square) in the basic shapes. Source: authors.

Circle and Triangle				
derivatives	basic sections	derivatives	basic sections	geometric sections
				 on the center
				 on the vertices
				 on the sides
				 on the axes

Fig. 4. Geometric transformation (combination of the rectangle and the circle) in the basic shapes. Source: authors.

<p>Baladieh building (Qajar - 1866)</p>	<p>In this period, the overall form of the building, the apertures, and the ornaments are shaped of simple sections from circles and squares, and the major used processes are the simple processes of combining a circle and a square around the center of the circle and the deflection process on the axis.</p>
<p>Baladieh building (Qajar - 1887)</p>	<p>In this period, Baladieh building was renovated and the hallway was extended to the building. Alike the previous period, the overall form of the building, the apertures, and ornaments are formed of simple sections of circles and squares; however, the simple process of combining the square and the circlr (on the center of the circle) was accompanied by the process of the changing of the angle and transformation of a circle to an ellipse.</p>
<p>Baladieh building (Pahlavi I-1937)</p>	<p>In this period, acute and triangular sections are observed in the facade. A clock element was added to the hallway and three processes are observed at this stage of time; combination of the circle and square based on the square vertices, combination of the circle and square based on the vertex of the circle, as well as the combination of the circle and triangle.</p>
<p>Baladieh building (Pahlavi II-1951)</p>	<p>Having added an entrance in this period, the clock element above the hallway was transformed and the building was completed using a combination of complex processes. The pattern used in the construction of the clock element above the hallway was shaped by deflection process of the circle on its diameter as well as the angle process</p>
<p>Baladieh building (Pahlavi II-1957)</p>	<p>In this period, Baladieh building spends its last days of existence regarding a different change of the hallway in comparison to the previous periods. At this stage, the hallway is thoroughly transformed following the patterns of modern architecture and the angle transformation process of square to rectangle.</p>

Fig. 5. The evolution of Imam Khomein Square (Tupkhaneh) in Tehran from Qajar period (construction time) to the contemporary era, categorized according to the four main directions. Source: authors.

of each table. The yellow sections represent the adapted pattern derived from the combination of two or more processes. They are considered as an added element and a distinguishing feature in the facade compared to the previous period.

At this stage, the prevailing geometric patterns of every period is introduced by recognition and re-reading of ornaments and the overall forms of the building facades as well as the adaptation of the basic

shape patterns to façade elements. Having identified these patterns, the geometric aspects of façade design and the significance of geometric transformation and combination can be acknowledged in each period.

A) Adaptation of the north façade to the geometric patterns (Fig. 6):

B) Adaptation of the south façade to geometric patterns (Fig. 7):

C) Adaptation of the south façade to geometric

patterns (Fig. 8):

D) Adaptation of the south façade to geometric patterns (Fig. 9):

The evolution process of geometric patterns

Having identified the basic shapes and their transformations, a framework called the Pattern of Geometric Transformations was achieved in this paper in which the geometric patterns and

appearance properties of facades (including the total combination, apertures and ornaments) were adapted and compared by historical-evolutionary categorization. In addition, the trajectory of these changes was searched by investigating the evolution of the geometric patterns used in facades. Therefore, in the table below, the facades located at the four main directions around the square were presented in form of a linear spectrum from Qajar period to

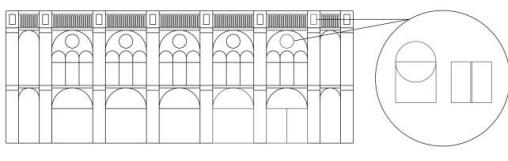
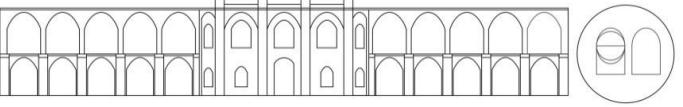
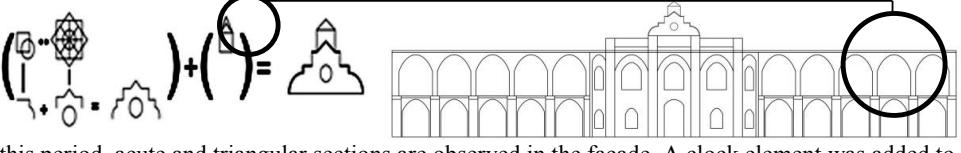
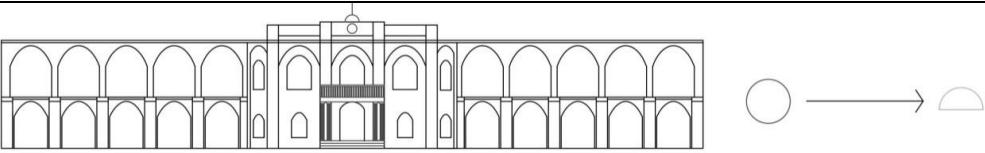
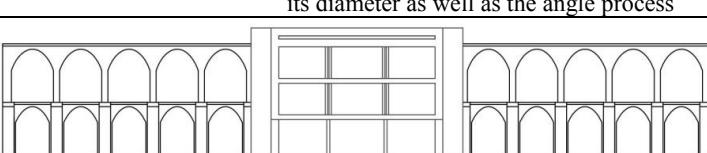
 Baladieh building (Qajar - 1866)	 In this period, the overall form of the building, the apertures, and the ornaments are shaped of simple sections from circles and squares, and the major used processes are the simple processes of combining a circle and a square around the center of the circle and the deflection process on the axis.
 Baladieh building (Qajar - 1887)	 In this period, Baladieh building was renovated and the hallway was extended to the building. Alike the previous period, the overall form of the building, the apertures, and ornaments are formed of simple sections of circles and squares; however, the simple process of combining the square and the circle (on the center of the circle) was accompanied by the process of the changing of the angle and transformation of a circle to an ellipse.
 Baladieh building (Pahlavi I-1937)	 In this period, acute and triangular sections are observed in the facade. A clock element was added to the hallway and three processes are observed at this stage of time; combination of the circle and square based on the square vertices, combination of the circle and square based on the vertex of the circle, as well as the combination of the circle and triangle.
 Baladieh building (Pahlavi II-1951)	 Having added an entrance in this period, the clock element above the hallway was transformed and the building was completed using a combination of complex processes. The pattern used in the construction of the clock element above the hallway was shaped by deflection process of the circle on its diameter as well as the angle process
 Baladieh building (Pahlavi II-1951)	 In this period, Baladieh building spends its last days of existence regarding a different change of the hallway in comparison to the previous periods. At this stage, the hallway is thoroughly transformed following the patterns of modern architecture and the angle transformation process of square to rectangle.

Fig. 6. Adaptation and comparison of the north façade evolution to the geometric patterns. Source: authors.

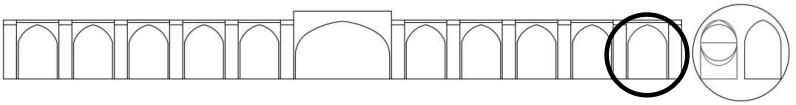
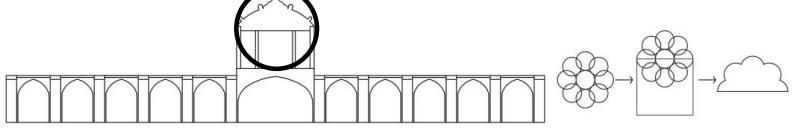
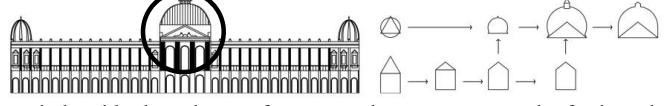
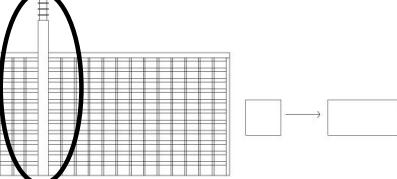
 South façade (Qajar - 1866)	 The general forms of the arches and vaults in the south facade are achieved by circle and square combination on the center of the circle. Here, the circle is turned into an ellipse in the process of angle transformation, by which the shape of the vaults is formed.
 South façade (Place of watching cavalry and infantry marching-Qajar-1979)	 In this period, a new ornamental pattern is observed above the south façade which is used as the place for watching military marching. In this pattern, the repetition of circles around a central circle based on the center of the circle along with the process of combination with square is perceived.
 Post and Telegraph building (Pahlavi I- 1936)	 In this period, with the advent of patterns that are composed of triangular cross sections, triangular shapes appeared in the façade, apertures and the overall form of the building such as the pediments above the entrance. The top dome form is created by two processes: 1. The combination of a circle and a triangle on the center of the circle; and 2. The combination of the triangle and the square based on the side of the square.
 Telecommunication building (Pahlavi II-1972)	 Following the advent of modern architectural principles, the overall form of the building and apertures are shaped by the process of angle transformation from square to rectangle.

Fig. 7. Adaptation and comparison of the south façade evolution to the geometric patterns. Source: authors.

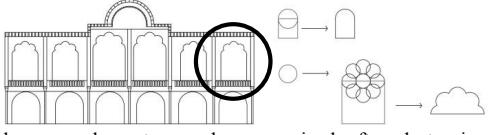
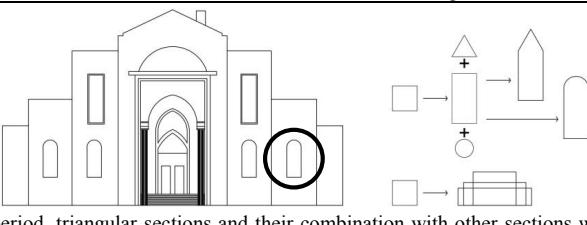
 Shahi Bank (Qajar- 1898)	 In this period, some elements can be recognized after destroying of the initial construction and the construction of Shahi bank. The general form of the arches is derived from the simple combination of circles and squares based on the center of the circle. As for the ornaments, the pattern is created by repetition of circles around a circle on the center of the central circle in combination with square.
 Bank of Commerce (Pahlavi I-1931)	 In this period, triangular sections and their combination with other sections were seen in the facade and the overall form of the buildings. In this building, the hallway form is created by the process of angle transformation by which square is turned into rectangle. The shape products were combined with the sections of the square and circle. Furthermore, the angle transformation process and changing of square to rectangle is observed in the overall form of the building.

Fig . 8. Adaptation and comparison of the east façade evolution to the geometric patterns.

Source: authors.

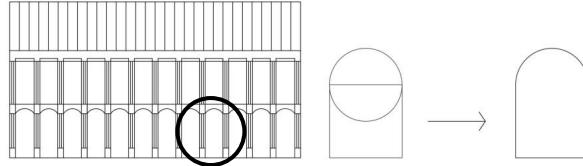
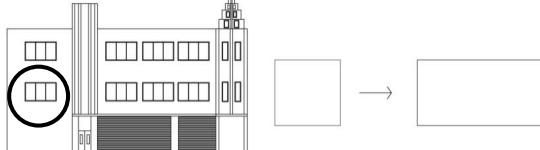
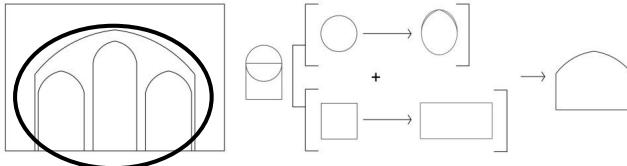
 <p>Police office and Traffic office (Pahlavi I-1909)</p>	 <p>In this period, triangular cross sections are observed in different parts of the building, including roof cover. The triangular patterns of Police office building are not visible from the square, and the building's patterns are created through traditional processes of combining circle and square and based on the side of the square which are obvious in the forms of the arches.</p>
 <p>Traffic office (Pahlavi II-1931)</p>	 <p>In this period, the dominant process is angle transformation and change of square to circle. In the structure of the road administration building, even the general triangular shapes used in the façade are resulted from overlaying of rectangular shapes in form of stairs (mastaba).</p>
 <p>Imam Khomeini metro station (contemporary-1999)</p>	 <p>In this building, the ideas of traditional and modern patterns are both used in the process of angle transformation and changing of circle into ellipse and square into rectangle. Subsequently, the shapes used in the façade are created by application of combination process.</p>

Fig . 9. Adaptation and comparison of the west façade evolution to the geometric patterns. Source: authors.

the contemporary era, and their shape transformation was explained in every box correspondingly. It was determined that during Qajar period (construction), the use of simple combinations of basic shapes with very slight changes in the overall form, apertures, and ornaments in the four directions surrounding the square are due to the simplicity of the design in that period. By commencing of Pahlavi I era and the arrival of modern style (Western architecture) and its integration with traditional architecture, we are dealing with complex patterns that are aimed at bringing the traditional architecture closer to modern architecture. During Pahlavi II era and following the unconditional acceptance of modern architecture principles (western architecture), the design are tended toward simple shapes in the overall form and apertures of the building (Fig. 10).

Achieving the geometric transformation

pattern in façade design

The evolution of the overall form, apertures, and ornaments in was achieved by arranging the building façades according to their time of construction and sorting and investigating their transformation. Since the main objective of this research is to recognize the prevailing geometric patterns in each period, the facades and the patterns are categorized based on the priority of recognition of the basic shapes and their evolution.

The first man-made houses were in circular shape, according to the technical principles and in order to solve the problem of ceiling spanning; hence, some people believe that humans inspired the circle from nature and its elements such as the sun and the moon (Leitkouhi, 2011). Among other examples of primary circular buildings is the widely known Arkaim citadel. It is located in the south of Russia (<http://arkaim.ru>) near Kazakhstan (5000 B. C.). Khosrowshahr

(Shah) building in Hamadan (5-4,000 BC) is another example. Therefore, the circle can be considered as the starting point for the geometric formation of shapes. Another well-known building in circular shape is the Stonehenge building in Salzburg in the south of England (Zarei, 2006).

Subsequently, the circle shape was transformed and turned it into irregular shapes by applying deflections and vertices which led to creation of irregular shapes similar to the rectangle and the square. The examples of these shapes are clearly evident in dwellings such as Teppe Zaghe formed thousands of years ago (about 4000 BC) with rectangular and unconstrained square plans. In the next stage, the attitude towards triangular patterns were observed in some buildings such as the Egyptian Pyramids (2500 BC) which were originally in the form of mastabas

(stepped frustum); (Zarei, 2006) (Fig. 13, 14). Euclid also categorized the circles, squares, and triangles as the basic shapes and introduces them as Euclidean shapes (D.K.Ching, 2006). As a result, the findings of the geometric patterns over time reveals that the circles can be considered as mother of shapes from which the squares and triangles are derived (Fig. 15). In the following, the typology of the evolution of the facades surrounding Imam Khomeini Square (Toopkhane) in Tehran was achieved through classification of facades and their geometric patterns regarding the prevailing geometric shape in every era due to the technique of implementation, the degree of Western architecture influence and other factors. Therefore, the dominant shape in every period is recognized by categorization of changes in basic shapes (and their hypernyms) as well as the

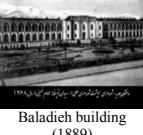
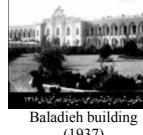
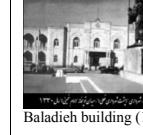
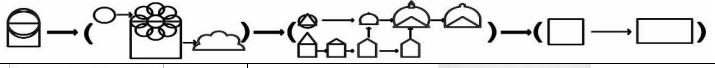
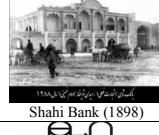
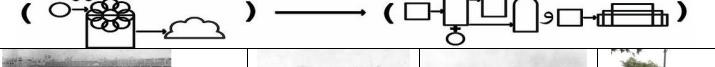
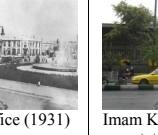
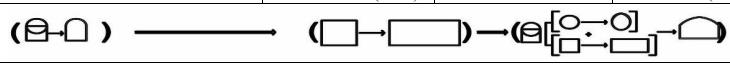
	Qajar period	Pahlavi I period	Pahlavi II period	Late Pahlavi II and the contemporary period
North side, from Qajar period to the contemporary time	 Baladieh building (1866)	 Baladieh building (1889)	 Baladieh building (1937)	 Baladieh building (1951)
				
South side, from Qajar period to the contemporary time	 South side (place of cavalry and infantry marching-1889)	 Post and Telegraph building (1936)	 Telecommunication building (1972)	
				
East side, from Qajar period to the contemporary time	 Shahi Bank (1898)	 Bank of Commerce (1931) - current Tejarat Bank		
				
West side, from Qajar period to the contemporary time	 The uniform west facade before destruction	 Police office and Traffic office (1909)	 Traffic office (1931)	 Imam Khomeini metro station (1999)
				

Fig. 10. The evolution of geometric patterns in the mentioned facades from Qajar period to the contemporary era. Source: authors.

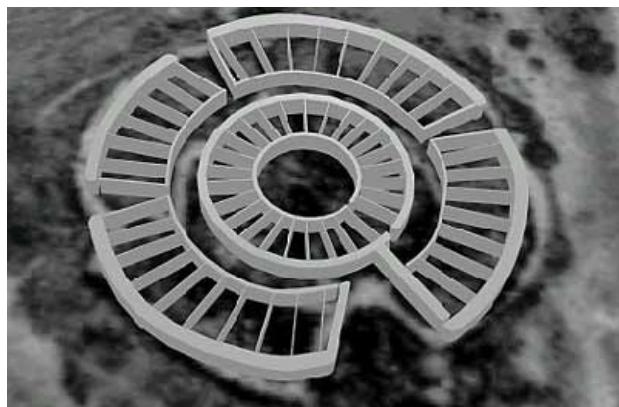


Fig. 11 & 12. Arkiam citadel in Russia and its circular shape. Source: <http://senyawa-kimia.blogspot.com>

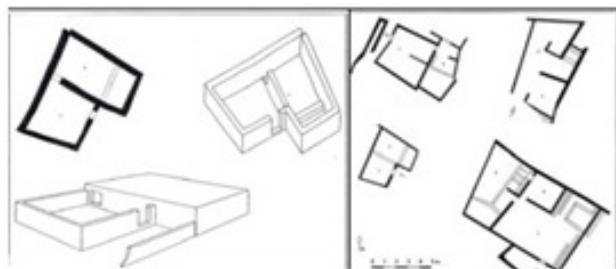


Fig. 13. Teppe Zage. Source: Introduction to world architecture.
Source: author.



Fig. 14. The Egyptian pyramid.
Source: <http://senyawa-kimia.blogspot.com>



Fig. 15. The pattern of transformation in the basic shape. Source:
author.

classification of facades. Concerning the evolution of geometric patterns, 5 milestones in façade design were recognized. These milestones were identified as circles, squares, triangles, circles, and ultimately squares, respectively (Fig. 16).

The above comparison and classification reveals that most of the geometric patterns used in the facades of the surrounding monuments during Qajar period were formed of simple shapes such as the circles and squares or their combination according to the center of the circle or in the process of repetition. During Pahlavi I, the triangular shapes and sections with acute angles were appeared in a variety of combinations

with circles and squares. As for the Pahlavi II period, the influence of Western architecture issued simplicity and prevented ornaments in various constructions of different functions. As a result, the geometric patterns used in this period were mostly squares and the products from square rotation in angles to the extent that in the present day the use of curved and diagonal lines, which are by some means derived from the circle, are used only as a symbol of traditional and past architecture (Fig. 17).

Discussion (Analysis of the findings)

Considering the importance of façade design in terms of visual significance in architecture, it is necessary to establish a specific method in designing the building facade and ease the reading of the facades of valuable monuments in order to preserve their

The process of using basic shapes along the course the square evolution					
North side, from Qajar period to the contemporary time					
South side, from Qajar period to the contemporary time					
East side, from Qajar period to the contemporary time	There is no evidence of the uniform east façade				
West side, from Qajar period to the contemporary time					

Fig. 16. Categorization of geometric patterns and facades around the square based on the evolution of the basic shapes. Source: author.

historical-cultural authenticity. Therefore, the shape patterns derived from the geometry science have to be studied in this paper. For this purpose, the present research is carried out in three stages: 1. Identifying the basic shapes, their transformations and, their geometric derivatives: At this stage, the basic shapes known by some scholars such as Durand and Krier were introduced; and the square, the triangle and the circle were defined as the basic geometric patterns. Thereafter, the transformation principles on the symmetry axis presented by Durand including rotation, repetitions, reflections and deletions; and the geometric processes introduced by Krier such as transformation, overlaying, merging, addition, sector, and angle were applied to the shape properties such as vertices, sides, centers, and axes in order to achieve a certain geometric process based on geometry principles. The resulting processes were: deflection, repetition, angle, and combination. Eventually, the recreation of the studied shape formation processes with respect to the geometric properties of the basic shapes led to recognition of the geometric patterns as referable shape patterns.

2. Identification of the transformations in the facades of buildings surrounding Imam Khomeini Square (Toopkhane Square) in the four main directions, from Qajar period to the contemporary era: At this stage, the visual information was collected using all available sources including books, internet sites, Tehran's old and current photographs, Cultural Heritage and Tourism Organization of Tehran and various types of visual media in the market that introduced Imam Khomeini Square, as well as taking pictures of the facades around the square. Thereafter a distinction was made between explicit, referable data and impaired, unidentifiable, misleading data. Eventually, the data (pictures) was classified based on the building location (north, south, west, and east) and construction time which was finally categorized in four periods of Qajar, Pahlavi, Pahlavi II and contemporary era.

In this regard, the vertical and horizontal data were compared by devising a table (Fig. 5). A vertical comparison reveals the physical evolution of the

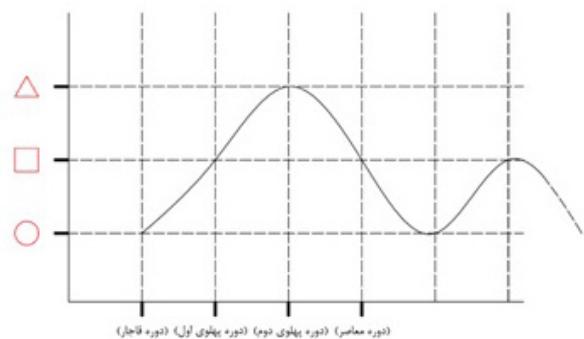


Fig. 17. The diagram of the evolution of the façade and the geometric patterns based on the basic shapes. Source: authors.

façade according to the construction time (Qajar period to the contemporary era). A horizontal comparison shows the basic shapes that were in common in all the buildings surrounding the square in each period. Thus, by comparing the buildings of Baladieh, Shahi Bank and the marching space, the presence of squares and circle in Qajar period was made obvious. By comparing the buildings of Baladieh (the hallway, the Bank of Commerce, the Post and Telegraph Building, Police office and the Road Administration building in Pahlavi I Period, the bold presence of triangle shapes was revealed. And finally by comparing the buildings of Baladieh (the latest evolution of the gate), the building of Telecommunications and the Museum of Industry in Pahlavi II, the presence of the square shape in this period became evident.

3. Adapting the geometric patterns with the obtained facades and identifying the process of geometric transformations: At this stage which was the final stage of this research, the geometric patterns and the facades of the existing buildings were adapted and studied. In this process, following the adaptation of the geometric patterns and the facades built on the north, south, east side of the square from Qajar to contemporary time, the followings were concluded:

A) North- Baladieh Building (Former Municipality):
1- Qajar period: In this period, when the primary foundation of the square was established during Nasereddin Shah Qajar's reign, by an order of Mirza Taghi Khan Amir Kabir in about ten years, the overall form of the building, the apertures, and ornaments were

configured using the simple circle and square sections. Moreover, the major processes used in these shapes were the combination of squares and circles based on the center of the circle and the square deflection based on the axis. Subsequently, this square was turned into Mashgh Square (infantry and cavalry marching space) and then changed into the artillery due to the fact that two important gates of the city were located in this area. Therefore, the square façade was rebuilt and a gate was added to Baladieh building which was located on the north side of the square. At this time, the overall form of the building, the apertures, and the ornaments consisted of simple sections of circle and square; alike the past period. However, this simple combination of the circle and the square (based on the center of the circle) was associated with the process of changing the angle of the circle (ellipse).

Pahlavi I Period: In this period, the triangular shapes in facades were used more often. A clock element was added to the hallway and three processes are observed at this stage of time; the combination of the circle and square based on the square vertices, the combination of the circle and square based on the vertex of the circle, as well as the combination of the circle and triangle.

Pahlavi II Period: having added an entrance in this period, the clock element above the hallway was changed and the building was completed using a combination of complex processes. The pattern used in the construction of the clock element above the hallway was shaped by deflection process of the circle on its diameter as well as the angle transformation process. Subsequently, in the last years of this period, Baladieh underwent a different change in the hallway and tended towards the modern architecture patterns by the process of angle transformation from square to rectangle.

4- The contemporary era: During this period, Baladieh building was completely destroyed, and shops and commercial units behind the building were known as the buildings behind the municipality. The abundant arrival of vehicles, as well as the expansion of the square space, and the displacement of the

municipality's building were factors in the destruction of the Baladieh building.

B) South – Military marching space, Post and Telegraph Building, Telecommunication Building:

1- Qajar period (Military marching space): In this period, the general forms of the arches and vaults are created by the combination of the circle and square based on the center of the circle. Here, the circle is turned into an ellipse in the process of angle transformation, by which the shape of the vaults is formed. In addition, a new ornamental pattern is observed above the south facade (the place for observing the parade) in which the repetition of circles around a central circle based on the center of the circle along with the combination process with square is perceived.

2- Pahlavi I Period (Post and Telegraph Building): In this period, with the advent of patterns with triangular cross sections, triangular shapes are observed in the façade, apertures, and the overall form of the building such as the pediments above the entrance. The top dome form is created by two processes: 1. the combination of a circle and a triangle on the center of the circle; and 2. the combination of the triangle and the square based on the side of the square.

3- Pahlavi II Period (Telecommunication Building): Following the advent of modern architectural principles, the overall form of the building and apertures are shaped by the process of angle transformation from square to rectangle. Therefore, the telecommunication building is characterized by patterns of Western architecture, and particularly modern style, in a simple cubic form, without any deflection and curvature in the building mass or diagonal and curved lines in the façade, by having rectangular elevated windows.

4- The contemporary era: In this period, the telecommunication building remains unaffected without any changes in the form and the facade.

C) East- Shahi Bank, Bank of Commerce (current Tejarat Bank):

1- Qajar period (Bank of Shahi): In this period, some elements can be recognized after the destruction of the initial construction and the creation of Shahi bank. The general form of the arches is derived from the

simple combination of circles and squares based on the center of the circle. As for the ornaments, the pattern is created by the repetition of circles around a circle on the center of the central circle in combination with square.

2- First Pahlavi Period (Bank of Commerce): In this period, triangular sections and their combination with other sections were seen in the facade and the overall form of the buildings. In this building, the hallway form is created by the process of angle transformation by which square is turned into a rectangle. The products were combined with the sections of the square and circle. Furthermore, the angle transformation process and changing of the square to the rectangle is observed in the overall form of the building.

3- Pahlavi II period (Bank of Commerce): During this period, the Bank's building did not change.

4- The contemporary era (Tejarat Bank): In this period, the Bank of Commerce has been renamed to Tejarat Bank. No alterations were applied to the form and appearance of the building other than the few required repairs.

D) West- Police office, Road Administration building, Museum of Industry building, Imam Khomeini Metro Station

1- Qajar period: There is no vivid document of the west side of the square in this period. Only a few historical documents indicate that this side of the square had entries to the place of storing ordnances (artillery) and weapon warehouse (the place of manufacturing weapons). It also led to Shahi (royal) mansion whose entrance was renamed as the gate of the National Garden in the next period.

2- Pahlavi I Period (Police office, Traffic office): In this period, the patterns of using triangular cross sections are observed in different dimensions, including the roof cover. In the police office building, the use of triangular cross section is not visible from the square, and the used patterns are created through the traditional process which is the process of combining the circle and the square based on the square side in the form of the vaults and arches.

3- Pahlavi II period (Traffic office): In this period, the

patterns are dominated by the process of angle and the transformation of a square to a circle. In the road administration building, even the overall triangular shapes used in the building façade are created by overlaying of rectangular shapes in form of stairs (mastaba).

4- the contemporary era (Imam Khomeini Metro Station): In this building, the ideas of traditional and modern patterns are both used in the process of angle transformation and changing of a circle into an ellipse and a square into a rectangle. Subsequently, the shapes were used in the façade by application of combination process.

Subsequently, the geometric evolutions of the patterns in the mentioned period are discussed. Then, the visual documentations of each side (the facades of studied buildings) are put in a row Fig. 10 and the geometric patterns used in the façade are displayed respectively. As a result, the geometric pattern transformation in every period is achieved by putting the facades (in terms of the overall form, apertures and ornaments), and the geometric patterns of the facades into scrutiny. Consequently, in this process, the geometric patterns used in each period are introduced as their indicators of the geometric pattern. In order to find out which geometric patterns are superior according to shape approaches, a table for evaluation of geometric patterns regarding the criteria of basic shapes was devised. In this table, the value of the existing shapes based on the time sequence of the human recognition of the geometric patterns (circle, square, and triangle) was mentioned. Hence, according to the findings and the documents, the first geometric shape recognized by human beings and used in architecture was the circle, after which the square (irregular quadrilateral) and the triangle were known. Hence, the triangle, square and circle have the highest and lowest values respectively. Finally, using the geometric value table and the classification of geometric pattern table and the evolution of façades around the square based on the basic shapes (Fig. 16), the table of the value of facades and geometric patterns in Imam Khomeini Square in Tehran (Fig. 17) is obtained.

Summary and Conclusion

The architecture science is continuously derived from geometric principles in which the design lines are organized in a mental process by the designer. In this regard, the application of geometric patterns has a significant role in designing the plan as the building map, in scheming the façade as the building appearance, and in creating the mass as the building form. Identifying the basic shapes and their geometric combination methods do not go far beyond the expectations of recognizing the past used patterns. Therefore, considering the importance of the façade design in terms of visual significance in architecture, it is necessary to achieve a specific method in design and ease the reading of the facades of valuable monuments in order to preserve the historical-cultural authenticity. In order to achieve this goal, the shape patterns that are obtained by use of geometry are required. The importance of recognizing the prevailing geometric pattern in each period was displayed in the presented typology of shapes, which led to further understanding and reading of building façade. Moreover, it revealed the importance of using geometric principles in the design which undermined mere imitational consumer-oriented approach and highlighted the significant role of geometric design in architecture.

As a result, the followings are achieved in this paper by comparing and categorizing geometric patterns and their adaptation to the transformed facades over time:

The most of the geometric patterns used in the facades of the surrounding monuments during Qajar period were formed of simple shapes such as circles and squares or their combination according to the center of the circle or in the process of repetition. During Pahlavi I, the triangular shapes and sections with acute angles were appeared in a variety of combinations with circles and squares. As for the Pahlavi II period, the influence of Western architecture issued simplicity and prevented ornaments in various constructions of different functions. As a result, the geometric patterns used in this period were mostly squares and the products from square rotation in angles.

Endnote

1. Pierre-Simon Laplace (French mathematician, physicist, astronomer, and philosopher; 1827-1749)
2. Gaspard Monge (French mathematician, physicist, chemist, who researched in some branches of geometry; 1718-1818)

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