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MATHEMATICAL-ARTISTIC SOLUTION OF THE MOLECULAR STRUCTURE OF ORNAMENTS IN ARTISTIC DESIGN

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Abstract. The paper examines ornaments in design and decorative-applied art, applying methodologies based on logical-mathematical-artistic solutions. We focus on the molecular structure of geometric ornaments and the special role of spatial thinking in their application, design or restoration. It has been shown that an infinite number of molecular geometric ornamental elements can be created, and implemented in accordance with strict scientific, molecular, chemical and geometric principles.

Keywords: *geometric-molecular ornaments, symmetry, composition, architecture, design, spatial thinking, multidisciplinary integration.*

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1. Introduction

The paper comprehensively examines both decorative and constructive geometric molecular ornaments, which decorate various areas, in terms of mathematical and artistic solutions.

It is known that human creativity cannot reach its full potential without using and applying scientific methods. The natural sciences are integrated into all areas of the arts or the humanities, where precision is essential. In this case, the longevity of creative work helps to clarify the art history of the country and people it represents. There have always been interesting approaches in this area. However, turning it into a theory and explaining the scientific aspects of their work to artists is being studied as an urgent problem of the day.

As a result of consistent development, ornament can become a component of visual attraction that is full of deep meaning, known and unknown quantities. Ornaments with a geometric structure could be very colorful in shape, color and content, but in fact they are ambiguous and deep. Scientists from many countries have done interesting research in this area.

The well-known Azerbaijani crystallographer Khudu Mammadov studied the use of symmetry elements in patterns, the subordination of ornaments on ancient objects to symmetry, the filling of architectural monuments with a three-dimensional axis of symmetry. Emphasizing that the structure of certain crystalline substances is the same, the valuable scientist created a set of backgroundless tables based on different types of fragments, using the laws of symmetry and the principles of close arrangement (Mammadov, 1981).

Architect Davud Akhundov gave a volume-spatial solution in architecture on the basis of systematization and comparative analysis of his investigations. That is, in architecture, he connected the transition from plane to volume, and the transition from volume to plane in geometry with a straight and reverse direction (Akhundov, 1986).

Turkish ornament researcher Avshar Lutfi studied the shapes and features of decorative elements in jewelry on the basis of both archeological and modern materials. He can show by examples that geometric ornaments, which decorate all areas between the past and the future, are of special importance in the field of decorative design (Avşar, 2012).

Researchers working in this field can also confirm that there is a mathematical-geometric-logical unity between the natural sciences and art, especially in all areas of decorative-applied art. Nikos Salingaros, who is also a mathematician and Michael W. Mehaffy brought significant innovations in the theoretical and practical application of real geometric factors, symmetry and other laws of harmony in the fields of architecture, urban planning and design, is of interest in this integration.

Based on his research, Salingaros notes that the perfect structure-aesthetic image, the law-based construction of symmetries and its artistic design are among the means that have a very high impact on people's mood. The human brain first analyzes architectural elements by grouping them artistically and mathematically. If artists do not make orderly, mathematically intelligible elements of the same size and shape, then there can be no symmetry. Symmetry, which is of particular importance in different forms of architecture, is dominant in traditional and local architecture (Salingaros, 2020).

According to Salingaros the universe works in normalized dynamics. Inside the symmetry of apparent order of these dynamics there is chaos, and inside the chaos there is a deeper order. This is the principle of the symmetric mathematical approach, which is the same in diversity, and this symmetry is regulated by nature itself. That is, if the symmetry of the Universe is violated, there can be no precision, no mathematical and artistic value. According to Salingaros, beauty in art is combined with the laws of symmetry. Considering mathematics as one of the most important historically important values of architecture, he shows that the ideal architect must also possess select mathematical knowledge. In this case, he can perceive the building mathematically, both completely constructively and decoratively.

Aesthetic mystery and romanticism in architecture help a designer determine the relative sizes and tectonics of architectural components. On the other hand, architects can give a mathematical definition of beauty with their works. Just as architects need to know the secrets of mathematics, so designers need to rely on hidden mathematical methods in formwork. Beauty is a structure that attracts people in such a way that it can be integrated based on different types of symmetry. Based on his investigations og built examples, Salingaros demonstrates that symmetry, as a complex system, has more helical, rotational, and scale symmetries in plants than in the universe, in nature, and in animals. He emphasizes that life creates a symmetry that seems structurally meaningful to us. In this sense, architects, as well as creative people, have a mental model of the environment. Nature itself has the ability to create true mathematically and biologically based beauty in architecture and design (Salingaros, 2020).

Design philosopher Michael W. Mehaffy forms his hypotheses based on the symmetrical meanings of architecture related to mathematics by Salingaros. Thus, by studying the role of theories of symmetry in all areas of architecture, he determines that

architecture and urban planning are based on real geometric factors with the advantages of the natural environment. He makes interesting hypotheses about the laws and symmetry by conducting new research in human biology, medicine, psychology, design and other fields (Mehaffy, 2020).

2. Parallels between man-made ornament and molecular structures

An interesting idea may arise from such research that if the accuracy of the works of local art of all peoples, regardless of religion, language or race, is obtained, the ornaments created there can last longer with their scientific names. We also propose a new approach based on this scattered research. Thus, by giving a parallel with the molecular structure of geometric ornaments and giving it a scientific name, we establish a useful framework for rigorous discussion. Giving a type of ornamentation its volumetric shape or projection based on geometric and perspective constructions, the plane position of ornaments clarifies the construction-reconstruction of ornaments on the basis of spatial thinking coming from an interdisciplinary integration.

Using these principles, the article also examines the ways in which all these features can be applied to molecular structural ornaments, such as meaning, beauty, harmony, filling the gaps, harmony and mathematics of the overall pattern composition in the construction of ornaments. Molecular-structured ornaments are called by a scientific name based on their semantic essence, and are presented in a permanent form without any distortion to the future.

2. Main part: molecular and crystallographic parallels with ornament

The integration of ornaments is understood as the formation of the structural relationships in the minds of people in order to form a whole and indivisible image of the world, to guide them to development and self-development. In modern world practice, with the help of scientific integration, people can synthesize the content they learn and the content they receive from outside. Basically, integration in the solution of design work of all fields of decorative-applied art implies the unity of all sciences, being perceived as interdisciplinary and supranational. In this scientific manner, a broad spatial thinking helps everyone, regardless of their specialization.

In the author’s opinion, the study of ornaments as an example of design in the space of interdisciplinary integration is a deeply important factor of scientific intelligence. A strong creative potential and spatial thinking help a person to solve this problem. Here a new molecular-based model of decorative elements is offered, which is of special importance in the artistic design of both decorative and applied arts and architectural structures.

Initially, it is noted that geometric ornaments define an infinite class of structures. For this reason, there are a number of views on their analysis. In all cases, ornaments can create a model based on the laws of general harmony, symmetry and geometric proportions, molecular and spatial structure. Spatial thinking is a very strong tool for specialists in restoring historical ornaments. Architectural structures with different surfaces, ornamental artistic epigraphic images on their surface always give great aesthetic pleasure to many people. At the same time, a perspective image creates a more vivid and complete picture than an axonometric image.

Even perspective structures are considered suitable for the restoration of curved surface architectural monuments that have been destroyed for some reason, or for the

compilation of three-dimensional drawings. Ornaments are occasionally damaged by various chemical or physical events.

It is very difficult to restore ornaments damaged during demolition or weathering to their original, natural state. Perhaps the restoration will be relatively easy if the surface on which the ornament is processed is flat. But usually the surfaces under process are not only flat but could be cylindrical, spherical, wavy, etc. Of course, restoration work on such surfaces is very difficult. To overcome this difficulty, perspective constructions and inverse geometric assumptions help restore architects, artists and designers. It is also important to build a model of the use of spatial thinking of the molecular structure of ornaments with reference to perspective structures.

The art of depicting objects on the plane has been known since ancient times. Images were usually displayed in isometry or frontal dimetry, which preferred to combine different images in order to develop spatial perception.

The famous scientist A.I. Dobrakov used the theory of shadow formation in the architectural and engineering-construction designs. Many prominent scientists studied the problems of reverse geometry and perspective, and they have contributed to the development of spatial thinking by providing a graphical construction of the descriptions of spatial forms on the plane (Pashayev, 2014).

The integrity of a beautiful effect is not a simple sum of beautiful parts, it requires harmony and subordination to create an artistic unity. The elevation of harmony, balance, as well as proportionality in nature and art to the level of human activity is the basis of the Greek philosophical concept (Arts and Crafts Movement, 2012; Efendi & Efendi, 2002).

Architecture is one of the forms of material culture and art associated with the development of science and technology.

The meaning of artistic images of architecture, the organization of space, the discovery of the proportions and rhythmic structure of parts and wholeness, with its artistic and monumental forms, always affects the environment. Even the Pythagoreans once viewed mathematics as a means of understanding the importance of being able to apply the laws of nature along with art to reveal the harmony and perfection of mankind.

The role of mathematics in discovery the secrets of art has attracted the interest of many geniuses. The meaning of “look for art in mathematics” is proof of this. As in nature, the hidden connection between the material, structure and parts of ornaments in architectural monuments is governed by the law of harmony. Completeness, unity, integrity, proportionality (geometric proportionality based on the laws of harmony) is in fact a problem of hereditary form (Dunyamaliyev, 2014).

Each pattern and ornament involved in the construction of mathematical-logical-artistic models in design works of different formats has its own constructive and decorative meanings.

Geometrical structures based on the precise mathematical formulas that form the basis of the artistic design of architectural structures are required to restore the ruined ornaments over time. For this, creative people must pay attention to the theoretical explanation of the ornaments, which they practically work on monuments, on a scientific basis. In this case, the combination of theory and practice is completed with a

beautiful ending. For example, in the tomb of the nun with a decahedron body, the ornaments create a visual shadow on the arches with a deep shadow pattern.

In this case, the combination of theory and practice ends with a beautiful final. For example, in the Momina Khatun Tomb (Nakhchivan city, Azerbaijan) with a ten-faced body, decorations create a visual shadow on arches with a deep shadow pattern. That is why such works of art have always existed since the Middle Ages, because they have a deep scientific nature. Geometric ornaments predominate in all these buildings and monuments associated with the name of architect Ajami Nakhchivani, which is considered the pinnacle of his creativity as an art motif. Just as the elements of the ornament in all his structures create a more complex and sophisticated image, for example, a rich and coherent inscription, they can also be called geometric molecular ornaments (Encyclopedia of Nakhchivan Monuments, 2008). This can be seen in the example of the ornament on the surface of the Momina Khatun Tomb.

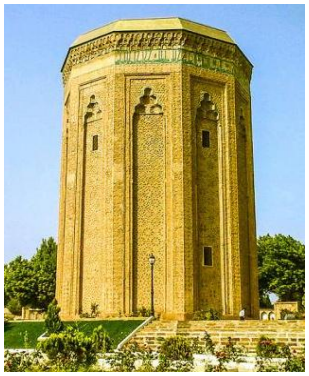
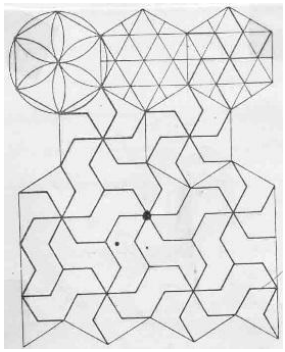


Fig. 1. Momina Khatun Tomb (Nakhchivan, Azerbaijan)



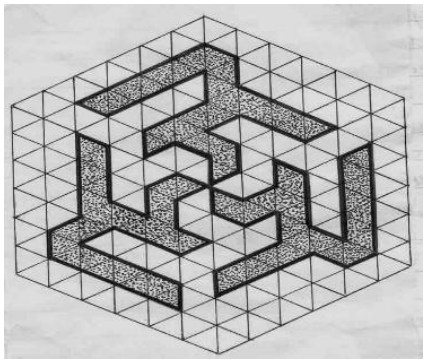


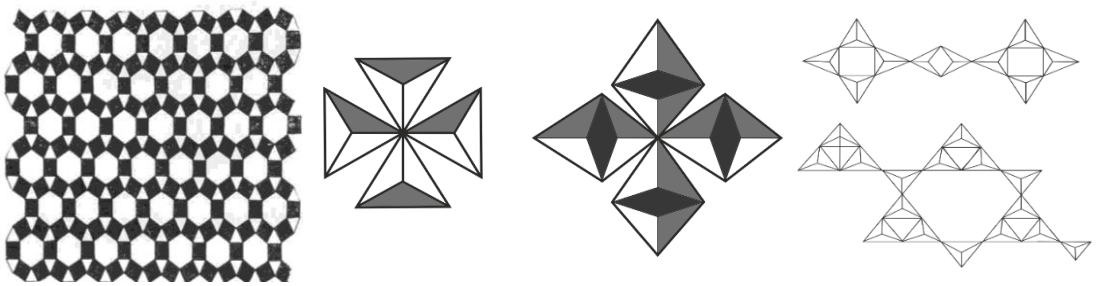
Fig.2. Fragments of the geometric ornament on the surface of the Momina Khatun Tomb

The basis of these ornamental descriptions is a molecular structure with a "cyclohexane" structure (Chiragov *et al.,* 2008). As can be seen, these ornaments are the result of a regular combination of hexagons drawn into a circle. An example of such a separation of patterns is the 6-fold repetition of the inscription of the word "Ali" on the front door of the Shirvanshahs' palace (Baku, Azerbaijan). The architect of the building worked very precisely, using the laws of symmetry, and fully ensured the parallelism of the sides of the geometric ornament to the side of the surrounding hexagon. Thus, any portions of the label in the direction of the sides of the hexagon are equal to each other. The circle inside the hexagon is divided into 12 equal parts equal to the font diameter and border thickness, and a border is drawn. The word "Ali" on the front door of the Sirvanshahs' palace is also an example of a geometric molecular ornament in which the cyclohexane molecule is given a "boat" form, three in white and three in black.

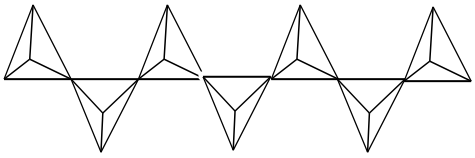
From the first simple division, it seems that the line surrounding any of the inscriptions is repeated when rotated 600 degrees along the plane of the ornament. This feature remains characteristic of all parts of the ornament. However, it can be shown for the first time that in the center of this article, six boat conformations of the cyclohexane molecule combine at one point, forming a very beautiful molecular geometric ornament. By giving the graphic structure of the molecule three white and three black colors, the pattern takes on a three-dimensional transition from a flat form to a three-dimensional system. Expressing the unity and inseparability of such sciences with such examples, it is possible to give the appearance and correct reproduction of ornaments in a three-dimensional system from a graphic image of chemical molecules.

These ornaments are used as a graphic representation of a closed spiro combination of six cyclopropane molecules. At the same time, these molecular ornaments can be viewed as a description of a polymer molecule assembled from flat graphic representations of cyclobutane, cyclopropane and cyclohexane molecules. These ornaments in general can be thought of as yet another example of an obvious molecular geometric ornament based on "polyspirocyclopropane".

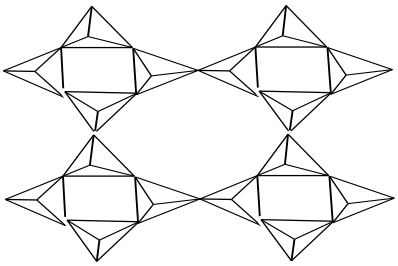
It is known that the structure of space and its graphic images express not only the sequence and valence of the atoms that form the molecule, but also the angle at which they connect relative to each other in space (Salahov *et al.*, 2005). It is possible to point to some examples of the infinite number of molecular ornaments based on polyspirocyclopropane, that if the ornaments are used in all areas of arts and crafts under their scientific name, such ornaments will be durable.



It is on the basis of these compounds that the tetrahedyrin chain and banded silicates covered the earth's crust. You can show a graphical description of these connections.



Chain type silicate



Tape type silicates

Graphic forms of spatial structure must accurately reflect the sequence and valence of atoms, as well as the angle at which they are connected in space. From this point of view, the description of the projection graph of the tetrahedral model of hydrocarbon molecules is very interesting. There are rules for constructing a number of tetrahedral models that clearly reflect the spatial isomerism for hydrocarbon molecules. Just as in the Middle Ages, the basis of the doctrine of harmonic ideas belongs to antiquity, so the history of the law of geometric proportions, which is its integral part, covers this period. The principle of geometric proportionality, which plays a decisive role in the creation of ornaments on the surfaces of architectural monuments with a perfect structure, along with the principle of construction based on molecular structure, also helps to reveal the scientific essence of these ornaments.

Continuing our consideration on the correspondence of such molecular ornaments to the laws of harmony, we can note that just as the structure and spatial categories of architectural monuments differ from each other, molecular ornaments created with ideal geometric regularity on different surfaces also obey the laws of harmony.

According to Khudu Mammadov, a well-known expert in crystal chemistry, who perfectly transferred its laws into art, creating various molecular structural ornaments, it can be noted that modern spatial chemistry is developing rapidly. It is important to determine the spatial structures of natural substances, the synthesis of compounds with a known structure, to find relationships between the spatial structure and physical and physicochemical properties, to study the reactions and mechanisms that provide these connections and the corresponding properties.

Creation of graphic images of the spatial structure of a molecule, assignment of names according to scientific nomenclature, construction of models and schemes, calculation of statistical and dynamically stable conformational energies of space chemistry and other issues are also important, important scientific and practical problems.

3. Conclusion

Molecular ornaments, like other ornaments, have special properties in practical and theoretical research, and even in technical inventions and solutions. These features, like beauty, are found in the bold search for ideas and imagination, in the intelligent solution

of scientific problems, in the correct analysis of facts, etc. From this point of view, it can be noted that one of the main factors that determine beauty in art, is the unity of artistic perfection, richness of content and perfection of form, the depth of the idea is applicable to molecular ornaments.

Given the huge number of molecules, an infinite number of molecular structural decorations can be created, and by giving them chemical names, we can emphasize that ornaments are based on the general laws of harmony, symmetry, and geometric proportions. At the same time, it is possible to construct geometric ornaments, group an ornamental lattice formed by geometric proportionality systems and, accordingly, molecular ornaments based on proportionality systems. Even the structural forms of such ornaments lead to the development of broad thinking, sensory growth of people, the enhancement of geometric thinking and the pursuit of purposeful search. It is possible to lay the foundation for a new scientific direction, creating geometric molecular ornaments, determining the correct chemical formula and applying it to the relevant areas of science, technology, art and construction.

By creating an infinite number of geometric molecular ornaments, when graphic images are aligned in any direction with an expectation of the order of valence, people study the principles of molecular geometric ornaments, confirm new or inextricable links between art and the exact sciences as they become semantic. According to Plato and Aristotle, and in ancient Greek philosophy, man was distinguished from other animals by the breadth of his spatial thinking, and his main feature is considered as a sign of the Divine principle. Plato stated that a person can approach the world of ideas, understanding what lies at the basis of what is perceived, and this is achieved through thinking. A person engaged in artistic creation realizes his aesthetic experiences and experiences, and this mission is included in the structure of the main practical activity.

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