pages: 1 - 10

BEAUTY OF NATURE'S FORMS IN CLASSIC APPROACH IN MODERN ARCHITECTURE

Marta Gołębiowska

West Pomeranian University of Technology, Faculty of Architecture, ul. Żołnierska 50, 71-210, Szczecin, Poland
E-mail: mwgolebiowska@gmail.com, ORCID: 0009-0006-8157-0268

DOI: 10.24427/aea-2023-vol15-06

Abstract
The author attempts to answer the questions, what is beauty in architecture and how the canon of beauty has changed in view of extending the possibilities of geometric control and the development of digital technology. The basis of classical beauty was the aesthetics of forms based on the belief that there was an objective beauty that the ancients understood mathematically. Using the achievements of predecessors gives us the opportunity to develop their thoughts using the principles originally laid the base for further research, or to widen the field of the methods used.
The modern science of beauty studies forms that come from nature. Studying the laws governing these shapes and proportions, we encounter the mathematical and geometric conditions in which Pythagoras and Plato found the secret of beauty. The subject of the article is to formulate the problem of searching for and creatively shaping an architectural form in a complex relationship to the generally understood nature through a research analysis of the theoretical foundations of the concept of classical beauty from a philosophical, artistic, mathematical and social point of view. The analysis of this issue shows nature as the main instrument in shaping the pattern of perfection and beauty to the present times.

Keywords: digital architecture; geometry; beauty in architecture; nature; bionics

INTRODUCTION

"We are accustomed to Cartesian systems of representation, in which every point of a form is projected onto a plane. Consequently, all forms that were difficult to project were qualified as bizarre. The difficulties encountered in introducing these forms discouraged their use. Conversely, there were forms in use whose projection presented no difficulties, such as the cube form. And yet, if a form is complicated to define in the Cartesian system, this by no means means that it is complicated to construct" [D.G. Emmerich 1965, p. 363].

Rasmussen claims: *"All art (...) is a way of expression, so what suits one artist may not suit another"* [Rasmussen 1999, p. 6]. The subjectivity of evaluations precludes the establishment of a single binding canon of beauty. However, it is not about the canon, but about establishing principles that dominate creativity. Harmony is a measure of consistency, logic and an element of consequence control. Although the beauty of architectural works is not described by a single theory, there are certain rules. Modern curvilinear forms of architecture with free geometry make it difficult to record harmony, yet architects strive to establish the principles by which they design.

Perhaps an information breakthrough and an increase in the efficiency of analysis will make these considerations more precise. Thus, they will become a stimulus for the interpretation of heritage, as well as a means of organizing the process of creating architecture.

1. CLASSIC APPROACH

Antiquity connected all areas of life, seeking common properties and regularities for them. The ancients sought rational justification for even the most ephemeral sensations [J. Słyk 2012, p. 39]. Thus, the basis of classical beauty was an aesthetics of forms based on the belief that there is objective beauty, objectively perfect proportions, which in antiquity were understood by the corresponding mathematical values. It was believed that objective beauty consisted of number and measure. The source of the principles defining beauty in modern architecture should be sought precisely in the classical period of Greek culture. The concept of classical beauty is presented from a philosophical, artistic, mathematical and social point of view.

1.1. The concept of beauty in ancient philosophy

In the Greek mentality, beauty was defined as that which is true and good, that which inspires admiration, liking, appreciation, and therefore that which, in the subjective perception, is worthy of endeavor and knowledge. *Kalós kagathos* is a Greek term meaning the inseparable combination of goodness and beauty which was used interchangeably [R. Turasiewicz 1980].

The incorporation of beauty and art into a single philosophical concept first occurred with Plato. *"If why is it worthwhile for man to live, it is for the beholding of beauty",* the philosopher wrote in *The Feast*. [Platon 2008] However, he praised something different from what we consider beauty in modern times. He used the term to include not only physical objects, but also moral and cognitive values. The question of beauty was posed by Plato many times. Its essence and correlates are considered in the dialogue *Hippias Major* in which he considers as many as five definitions: beauty is appropriateness, beauty is usefulness, beauty is utility and beauty is pleasure to the eyes and ears. However, the "enumeration" of examples of beautiful things presented by the sophist from Elida is ultimately rejected by Plato. This discourse opened the way for further speculation on what true beauty is.

In his later works, Plato leans toward the Pythagorean concept, defining beauty by order and measure, that is, by number and proportion. *"Measure and proportion are beauty and virtue"* or conversely, *"ugly is that which has no measure"* he writes in *Philebus*. [Platon 2021] With measure being understood in one case as number, in another as moderation and appropriateness. Plato, however, did not remain only concerned with theory, he gave concrete examples of good proportions. In the dialogue *Meno,* he takes as an example two squares in such a ratio to each other that the side of one is half the diagonal of the other - he has this proportion as perfect. For many centuries architects have based the proportions of the most monumental edifices (in the facade of the Parthenon, located on the Athenian Acropolis, St. Paul's Cathedral in London or the Marina Bay Sands building in Singapore) on such a ratio of two squares.

Aristotle claimed that the purpose of art is to imitate the beauty of the real world. The aesthetic views of Plato's disciple differ from those of the master in the same way that their philosophies differ. In Aristotle's case, the form is not only a reflection of the idea, but is identical with it. The artist, when depicting reality, does not have to imitate its image (appearance, form), but should depict its Being [W. Tatarkiewicz 1985].

Thus, the task of art is to present the truth, not blind and detailed imitation (mimesis). Beauty appears only when the material work in its sensually accessible form has certain qualities, such as proportions, order, purposefulness, etc., but they are expressed in a Pythagorean way. In *Book XIII* of the *Metaphysics*, Aristotle wrote: *"Those who say that mathematics says nothing about beauty and goodness are mistaken. /.../ The main features of beauty are order, symmetry, and necessity, which mathematics indicates in a special way."* [Aristotle 2016]

Socrates also contributed to the understanding of beauty, describing it as appropriateness and conformity to the purpose it is intended to serve. Augustine of Hippo combined the theory of harmony with mathematics and art, emphasizing the need to integrate beauty with the ethical order of life. Plotinus criticized the Pythagorean theory of beauty, noting that focusing only on proportion would limit it to objects. He pointed out that beauty also exists in color, sound and sunlight, not only in geometric proportions.

In ancient Greece, during the time of Thales of Miletus (635-543 BC), a catalog of basic concepts such as point, line, and angle was established. Tales noticed regularities resulting from their transformation. On the basis of Thales's thought, the Pythagorean school shows the unity of arithmetic, geometry, music and astronomy. Pythagorean geometry provided proofs of many theorems that form the basis of "traditional" geometry. Euclid in the geometric treatise *Elements* referring to the concepts: "magnitude", "ratio", "proportion", "multiplicity", he created a theory that forms the basis for what is still regarded today as a model of accuracy and conciseness of mathematical expression.

The duty of an architect, according to Vitruvius, was to ensure that buildings are not only durable and useful, but also beautiful. In Vitruvius's presentation, we find Euclidean geometry in its pure form. The definition presented in the second chapter of the first book uses four criteria for architectural composition. The first two concern shape and use the logic of scaling derived from the *Elements*. Ordinatio, or orderliness, is a general feature of a building that derives from the "numerical ratio" between the dimensions of the elements [R. Wittkower 1980]. Dispositio, on the other hand, defines the arrangement of elements in relation to each other, decorio as appropriateness and distributio as economy. According to Scholfield, the *Ten Books* can be considered a "broken link," a break separating modern Western architecture from the Greek tradition.

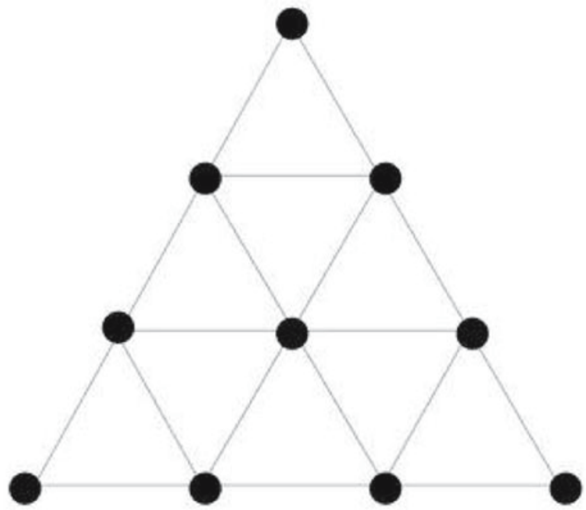

Fig. 1. Tetractys. Triangular figure as a mystical symbol of perfect proportion; source: drawing by the author.

The Pythagorean theory of beauty as a number was also referred to by St. Augustine, he wrote: *"reason (...) saw that only beauty is liked, in beauty - shapes, in shapes - proportions, in proportions - numbers"* [Św. Augustyn 1999]. In his view, beauty has objective value and does not depend on human judgment. *"First of all, I'll ask whether that's why something is beautiful, because it pleases, or why it pleases because it is beautiful. I will undoubtedly receive the answer that this is why it pleases, because it is beautiful. Then I will ask, in turn, why it is beautiful; and if he begins to hesitate, I will hint whether it is by chance because the parts of the thing in question are similar to each other and, through a certain mutual relationship, achieve conformity and unity"* [Św. Augustyn 1954].

The aesthetic achievement of the Pythagoreans boils down to the conclusion that all of nature is built according to some principle that can be written down in a mathematical (numerical) formula, but only certain ways of ordering (proportions) determine whether it evokes a positive experience of beauty. Modern architecture draws from the ancient tradition a sense of overall proportionality - the "consonance" of elements within a whole. When we adopt a new measure of proportionality, we can obtain a new harmony that gives a sense of order and beauty to an artistic work.

Behind various concepts of beauty are rules that people follow. Invariably, historical eras and certain cultures determine objects, forms or attitudes that are

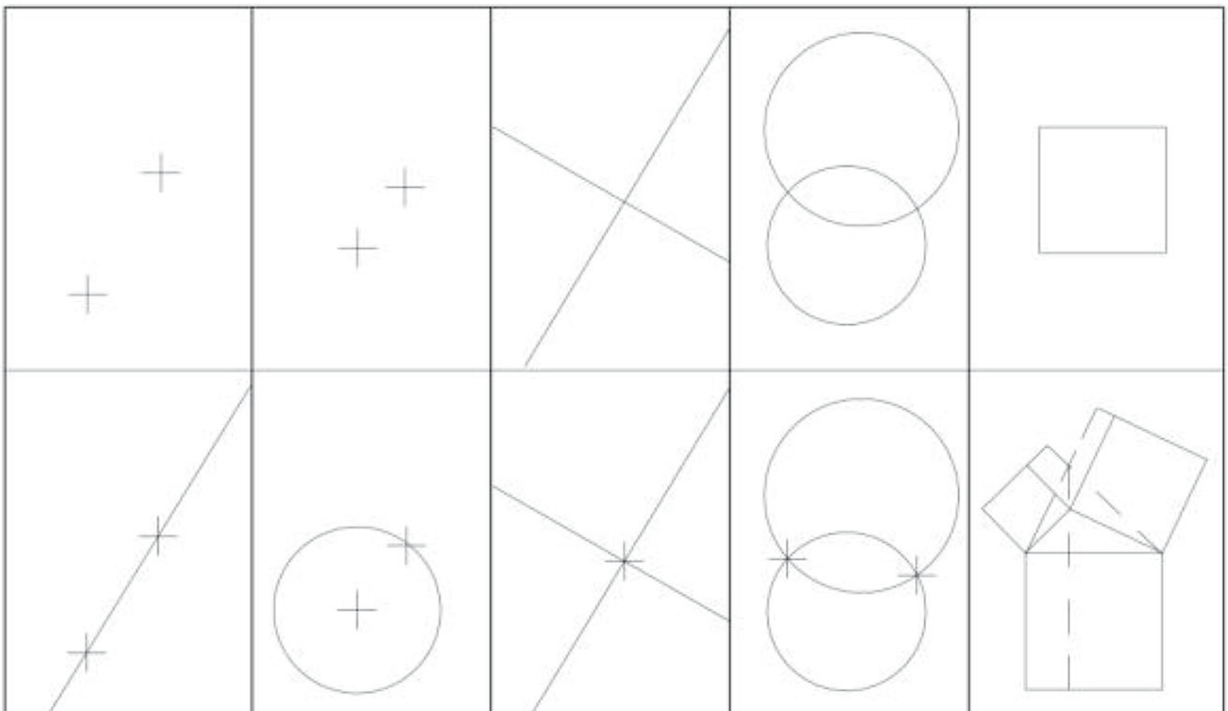

Fig. 2. Classical structures & classic geometry, which Euclides first described in *Elements* (IV, BC.); source: drawing by the author

considered good, to be admired and imitated. The line connecting the various "strong points" - the spiral of the golden division - can guide the viewer's eye. In this way, an image or form can become an engaging story. The principles of golden division used in architecture are considered and applied by architects even today.

1.2. Continuation of mathematical theories as a generative feature

In the 1970s, computers provided new design possibilities. The creation of arbitrary forms is no longer a problem, and the results achieved delight with diversity. Expanding the capabilities of the geometric control apparatus provides architects with access to new levels of regularity regarding shapes and the processes for creating them. Computers make it possible to automate many design activities. They automatically search and organize information, according to set criteria, participating in the analysis of conditions. At the modeling stage, they support the search and optimization of the form. With the help of software, one can find analogs of nature's creations and then use them in the creation process. Architecture can draw on relationships of a very complex nature. Commensurate, harmonic proportions, which are first observed in nature, then interpreted, provide endless inspiration for architectural works. However, the source of proportionality is always a mathematical rule.

The continuation of mathematical theories is a generative feature, providing new and unique data based on known values. Building on the achievements of predecessors provides opportunities to develop their thoughts using the originally stated principles as a basis for further research, or to expand the area of applied methods [J. Słyk 2012, p. 37]. The discovery of alternative geometries, the ability to analyze by digital means does not replace previous methods, but broadens the base of inspiration. Many architectural objects would probably not have been created without the freedom of imagination stimulated by modern mathematics. However, independently the basis is embedded in a traditional Pythagorean-Cartesian context. This applies to both design issues and aesthetic perception. Algorithmic creativity does not come from calculating machines. Rather, it was man, thanks to twentieth-century inventions, who faced the need to make a turn.

He did not invent, but discovered, or rather, reinforced a method of cognition that has always existed [K. Terzidis 2006]. Architecture, in order to be original, cuts itself off from the forms invented by its predecessors. In texts documenting the transformation of architecture, we find descriptions of new aesthetic systems. They focus on visual and emotional contexts, but often describe them in criteria of proportion and harmony. Sociology is increasingly willing to take up themes from the borderline of aesthetics, and as a result, the thesis of the "aestheticization of reality" is being pushed more and more boldly [K. Kociołek 2020], according to which aesthetic values are the primary criterion for choices.

1.3. Modern beauty - as an autonomous category

In modern architecture, conventions are mixed, and the concept of style is practically meaningless anymore. As Hans Georg Gadamer states: *"art demands a new legitimacy whenever the demand for new truth is opposed to traditional form"* [H. Gadamer 1993, p. 19]. The entire 20th century, however, is characterized by a situation in which the bold self-liberation from the historical bonds of the 19th century in another bold sense gives truth to the sentence that all previous art appears as something past. Observation of the evolution of the description of complex geometry may lead one to argue that the computerization of the architect's workshop has influenced the emergence of a new class of architecture. The works of Peter Cook, Zaha Hadid, Greg Lynn, and the Hyperbody group are associated with the inventions of the digital world, including, above all, the hardware that provides computational efficiency. While it is difficult to deny the influence of computers on free form modeling, the real breakthrough is not in machines but in architectural thought.

2. BEAUTY IN THE FORM OF NATURE

Architecture draws modularity from nature - the proportions of Roman temples were measured using units and relationships derived from observations of nature. This type of relationship remains the main instrument for shaping the pattern of perfection and beauty to the present day.

The modern science of beauty studies forms that have been created under conditions of undisturbed development such as crystals, vegetation, shells, bones, muscles. By studying the general laws governing these shapes and proportions, we discover a criterion of form in nature that we can apply to works of art and architecture. In this study, we encounter the mathematical and geometric conditions in which Pythagoras and Plato found the secret of beauty in number.

Most of Nature's patterns compared to traditional geometry are irregular and chaotic. This does not mean that nature now presents a higher level of complexity, but that we are now able to describe with the same rules a completely different level of its dimensio-

Fig. 3. Beijing Daxing International Airport, airport terminal building has been likened to a starfish, project Zaha Hadid Architects, 2019; source: Hufton + Crow, zaha-hadid.com

nality. The number of different subdivisions in natural patterns is essentially infinite. The existence of these patterns compels us to study the forms that Euclid dismisses as “formless,” to study the morphologies of the “amorphous.”

Alejandro Bahamón and Patricia Pérez in *Inspired by Nature: Minerals* [A. Bahamón, P. Pérez 2007] analyze designs and buildings inspired by solutions found in the world of geology, from the form of crystals to inspiration from earth sculpture, mineral voids, volcanoes and monoliths. Among the examples described by the architects are buildings such as a cinema complex (Coop Himmelb(l)au), museums (Daniel Libeskind and Tadao Ando), and a theater (Antoine Predock). Through visual analogies, they emphasize how architects create new, sustainable and efficient architectural forms by closely observing nature. The unnatural desire to absorb the structural efficiency of the beauty of a shell, husk or other natural shape has gained an ally in parametric design. The development of CAD technology has led to a state where the projection and processing of complex geometric forms is not a problem for architectural expression.

2.1. Lotus Temple, India

The unusual block, designed by architect Fariborz Sahba, is located in New Dehli, India. The temple is less than 40 meters high, and its shape is inspired by a half-open lotus flower. - in Hinduism and Buddhism, a sacred plant that is a symbol of beauty, purity and rebirth.

There is at least one Baha’i temple on every continent, and each is characterized by a unique architectural solution. All Houses of Prayer are in the shape of a decagon with nine entrances, topped by a dome. *“This is meant to symbolize the unity of the nine world religions and their openness to all people (…)”* [T. Jędrasik 2010, p. 16].

The lotus concept was described using geometric shapes such as spheres, cylinders, toroids and cones. The size, shape, thickness and other details of the structure were determined by the equations of the above geometric surfaces. These equations eventually transformed into a set of dimensions in terms of length, width, height and thickness. These were developed separately for each section of the temple. The structure was divided into 9 segments described relative to the center of the coordinate axis by an angle of 40 degrees to form a simple regular decagon. The lotus flower consists of 27 concrete “petals” clad in white marble.

By establishing rules of arrangement and shapes, the order read in the most exposed projection becomes a carrier of meaning. The sources of the spatial code arise primarily from structural considerations. The appropriateness of pattern and building in them must be understood as a mathematical transformation of natural inspiration - which is not so much an observation as an idealization. The principles of proportionality change, but the principles of creating patterns for them do not change.

2.2. Science Center in Glasgow, Scotland

The building, designed by Building Design Partnership, is located in a harbor promontory setting that allowed the organic form to be exposed. The creators were not accidentally inspired by the shape of the shell. Taking advantage of environmental conditions to incre-

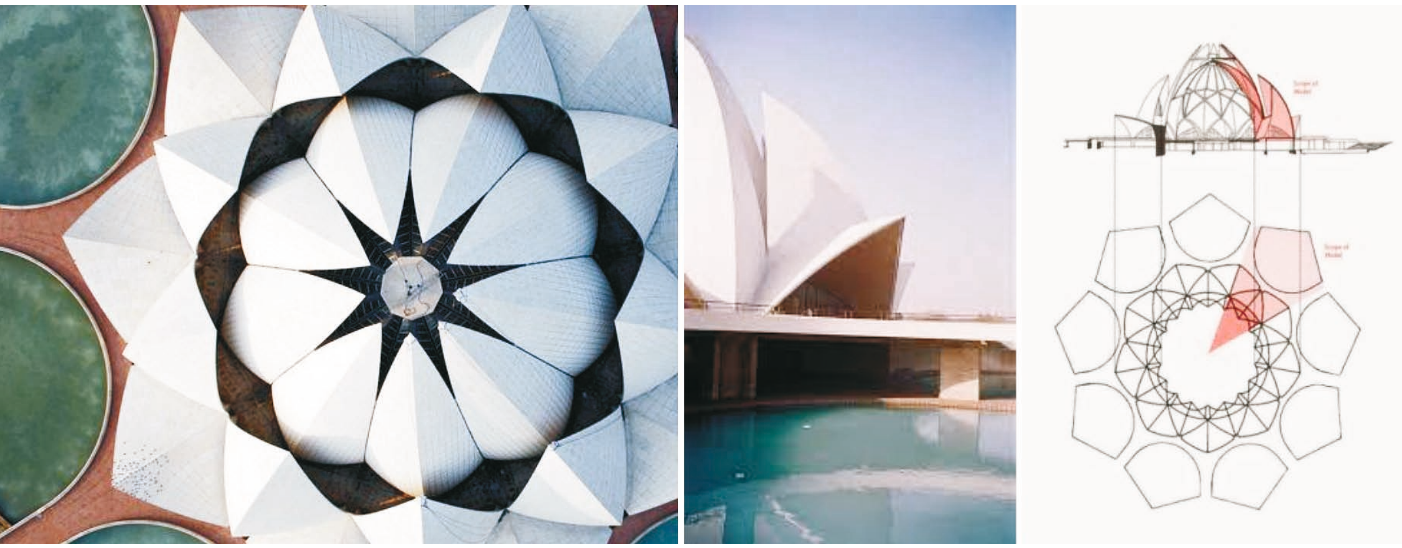

Fig. 4. Lotus Temple, New Delhi, India, project Fariborz Sahba, 1986; source: http://www.eioba.pl

Fig. 5. Glasgow Science Museum, Scotland, project of Building Design Partership, 2000-2009;
source: www.glasgowsciencecentre.org

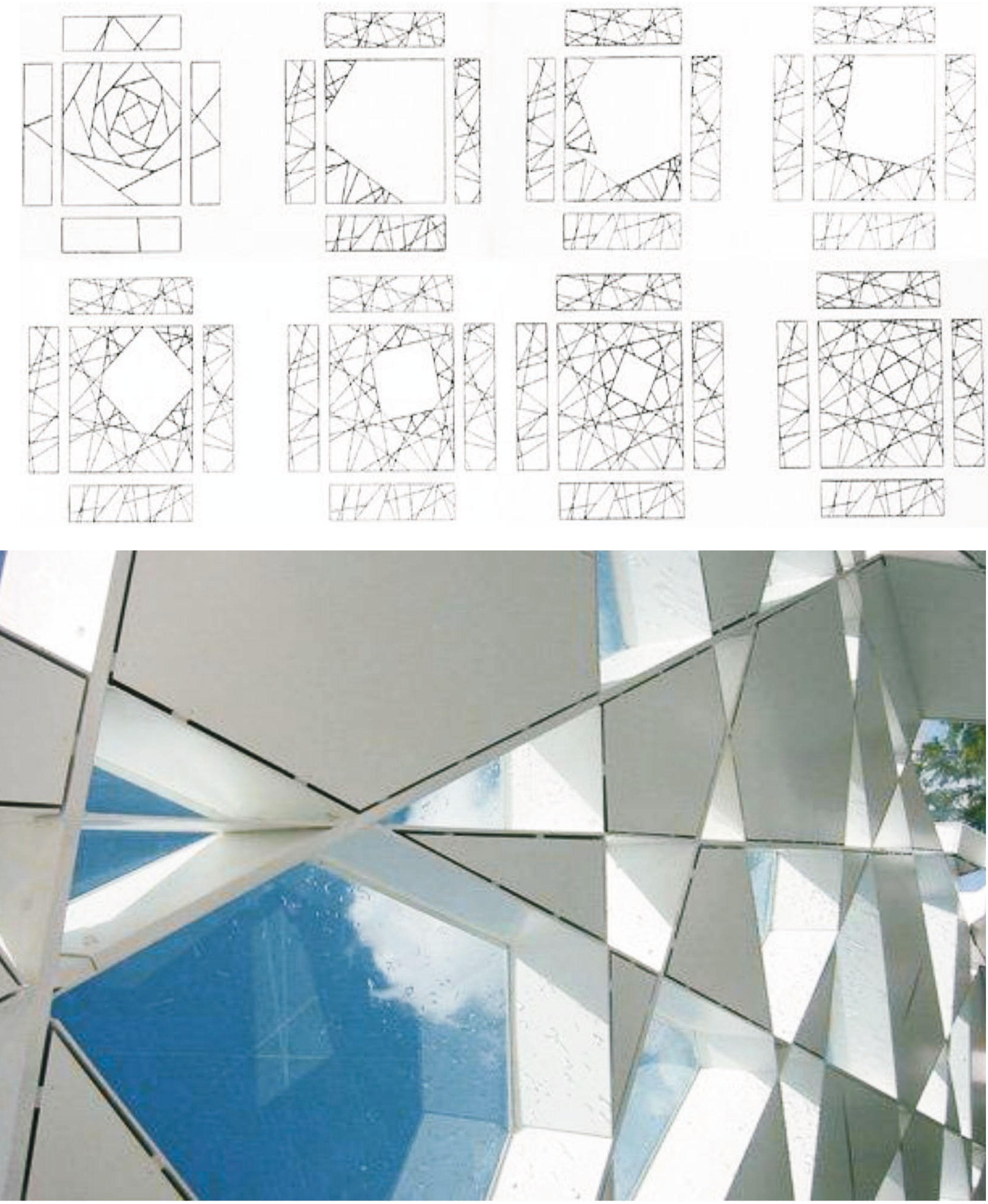

Fig. 6. Serpentine Gallery Pavilion 2002, London - Next steps in generating the construction system; source: openbuildings.com

ase the efficiency of buildings was one of the main postulates underlying the idea. The proper development of architecture comes with the increase of its adaptation to serve man through beauty and utility. For it to occur the concepts of form and function should not be treated in opposition, but should complement each other. Beauty in architecture was defined in this way already by Vitruvius in the verses of his treatise by the three main qualities of *firmitas, utilitas, venustas*, that is, durability, utility and beauty, respectively [Vitruvius 1956, s.16]. The building should be both fully beautiful and fully usable. The science center optimizes the penetration of natural light, and the outline of the slate roof reflects the sun's migration over the horizon. The glossy covering reflects southern light, minimizing the greenhouse effect. The entire structure resembles a natural object not only in shape [J. Słyk 2012, s.144].

2.3. Serpentine Pavilion

The Serpentine Pavilion already has a permanent place in the history of modern architecture. Every year since 2000, a different architect or studio has created a vision for a temporary summer pavilion in Kensington Park. This is always an important event for the world of architecture. Toyo Ito i Mutsuro Sasaki's aim during the work on the Serpentine Gallery Pavilion 2002 project, was to achieve a form that looked as random as possible.

To do this, they used simple mathematical relationships already described in a theorem in Book XIII of Euclid's *Elements* on the transformation of square geometry. The construction of the pavilion began with the division of the figure, determining the object's outline, by means of segments that are fragments of the same figure, but rotated by a certain angle. The next step was to type in a rotated square - typing another, smaller one also rotated into it. Fragments protruding beyond the square into which they were inscribed were discarded. This arrangement was repeated seven times (Fig. 6). As a result, a structure was created, giving the impression of a completely random division of the surface by lines, such as the grid of cracks in the ice cap. However, it is in fact a system of interdependent frameworks, representing an efficient structural system [R. Tarczewski 2011, p. 255]. The authors even state that: *"our goal became to find a rule, an algorithm that would generate chaos, with its inherent beauty, but possessing a hidden deeper order."*

CONCLUSIONS

New technologies do not stand in opposition to the classical notion of beauty, but offer the possibility of finding and developing it through new forms, for which the rules of harmony, geometry and proportionality are as relevant as in ancient times. Knowledge and philosophy have undergone changes since classical times, but the end result of inquiry is the same: number conceived as a mathematical principle is the basis of all forms measurably knowable by the senses, in which organic and inorganic matter is formed. Nowadays, technically, practically nothing limits us, but the concept of beauty in its classical formulation is still as important as it was for our predecessors. Ancient philosophers and architects devoted themselves to numbers and the relationship following them to bring them to perfect proportions. Today, in the digital age we get new opportunities to use the originally defined patterns.

The resource of nature's technology today is a new source of inspiration for designers who would like to move in the direction of using digital design tools that mimic natural formative processes. Engineering technologies can be abstracted from biological systems and translated into architecture. However, this process, known as biomimetic, requires an interdisciplinary approach to the design process.

Using examples of realizations of architectural objects determined by nature, the benefits of adaptability of their geometric forms for the search for optimal architectural forms are revealed. Design possibilities make it possible to create objects with more complex structure and form. Using digital tools in the process of searching for beauty of form in architecture reveals new perspectives. The complexity of this process is seen as a reflection of contemporary architectural trends, while at the same time emphasizing the sign of the times. Nature invariably remains its key element and inspiration.

LITERATURE

1. **Aristotle (2016),** *Metaphysics,* Hackett Publishing Co Inc. Indianapolis, IN.
2. **Bahamón A., Pérez P. (2007),** *Inspired by Nature: Animals, The Building/Biology Connection,* Barcelona.
3. **Emmerich D.G. (1965),** *Architectural Design 35*, July, p. 363.
4. **Euklides (2013),** *Elementy Teoria proporcji i podobieństwa*, Copernicus Center Press, Kraków.
5. **Gadamer H. G. (1993),** *Aktualność piękna*, Oficyna Naukowa, Warszawa.
6. **Kociołek K. (2020),** *Estetyzacja rzeczywistości – skutek dobrobytu czy upadek wartości? Analiza i krytyka poglądów Wolfganga Welscha dotyczących procesu estetyzacji*, "Analiza i Egzystencja", 52, 37-54.

7. **Platon (2008),** *Uczta*, Wydawnictwo Marek Derewiecki, Kęty.
8. **Platon (2021),** *Fileb*, Wydawnictwo Marek Derewiecki, Kęty.
9. **Rasmusen S.E**. **(1999),** *Odczuwanie Architektury,* Karakter, Warszawa.
10. **Scholfield P.H. (1958),** *Theory of Proportion in Architecture*, University Press, Cambridge.
11. **Słyk J. (2012),** *Źródła architektury informacyjnej*, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa.
12. **Św. Augustyn (St. Augustine) (1954),** *De vera religione*, *tłum. J. Ptaszyński: O wierze prawdziwej*, w: *Św. Augustyn, Dialogi filozoficzne IV*, Warszawa.
13. **Św. Augustyn (St. Augustine) (1999),** *De ordine, przeł. Wł. Seńko, w: Dialogi filozoficzne,* Znak, Kraków, p. 151-234.
14. **Tarczewski R. (2011),** *Topologia form strukturalnych, Naturalne i tworzone przez człowieka prototypy form konstrukcyjnych w architekturze*, Oficyna Wydawnicza Politechniki, Wrocławskiej, Wrocław.
15. **Tatarkiewicz W. (1985),** *Historia estetyki* Vol. 1,2, Arkady, Warszawa.
16. **Terzidis K. (2006),** *Algorythmic Architecture*, Routledge, Oxford.
17. **Turasiewicz R. (1980),** *Studia nad pojęciem «kalos kagathos»,* Zeszyty naukowe Uniwersytetu Jagiellońskiego, Zeszyt 41, PWN, Warszawa.
18. **Vitruvius (1956),** *O architekturze ksiąg dziesięć,* PWN, Warszawa.
19. **Wittkower R. (1952),** *Architectural Principles in the Age of Humanisium,* John Wiley & Sons, Londyn.