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PLAYING NATURE  
IN THE CONTEMPORARY SEARCH  
IN SHAPING STRUCTURAL SURFACES

GRA W NATURĘ WE WSPÓŁCZESNYCH  
POSZUKIWANIACH KSZTAŁTU POWIERZCHNI  
STRUKTURALNYCH

**Abstract**

The contemporary image of shaping modern architectural designs increasingly entails a synergy of design solutions in terms of form and structure. As a result, shaping integrated structures in the form of structural surfaces takes on particular importance. Modern trends are increasingly looking for analogies to the natural world. Playing Nature are projects inspired with cylindrical shapes, referring to the forms found in nature or using a bionic structure.

*Keywords: structural surfaces, bionic, biomorphism, curvilinear architecture*

**Streszczenie**

Współczesny obraz kształtowania nowoczesnych obiektów architektonicznych to coraz częściej synergiczne rozwiązania projektowe w zakresie formy i struktury budynku. Znaczenia nabiera kształtowanie zintegrowanych struktur w postaci powierzchni strukturalnych. Obecne tendencje w większym stopniu poszukują analogii do świata przyrody. Gra w Naturę to projekty inspirowane obłymi kształtami, nawiązujące do form spotykanych w naturze lub wykorzystujące bioniczne struktury.

*Słowa kluczowe: powierzchnia strukturalna, bionika, biomorfizm, architektura krzywoliniowa*

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## **1. Introduction**

The modern image of shaping architecture is seeking new forms in terms of geometry, space and structural surfaces. Increasingly, architectural projects refer to the forms found in nature. The development of digital tools used in the design process has enabled the development of irregularly shaped forms, resembling the aesthetics found in the natural world. The approach to the design process, which increasingly introduces interdisciplinary design, is also an important change. As a result, achievements from other fields are used in shaping architecture, which until now have not been associated with it. A number of new methods and design tools allow the architect to Play Nature in the search for processes and systems which form living organisms, the search for aesthetics, or analogous spatial forms. As a result, we can distinguish trends in shaping structural areas which affect the form and nature of architectural objects inspired by rounded elements from the natural world, forms found in nature, or the principles of living organisms.

## **2. Contemporary Trends in Shaping Structural Surfaces Inspired by Elements from the Natural World**

The forms found in the natural world have always interested and inspired architects. The development of building technology and design tools has enabled the use of a variety of references to the natural world in the contemporary architecture. As a result we can distinguish architecture that incorporates elements from the natural world in the development of architectural expression, biomorphic architecture, bionic architecture, and curvilinear architecture inspired by soft forms found in nature.

The application of simple analogies from the natural world was already visible in the historical architecture in the form of plant and animal ornaments. Today, replicating nature can be seen in architectural buildings, the form of which has been tritely shaped as vegetable elements or animal silhouettes, or may be a qualitatively new ornament in shaping a variable and dynamic architecture with the use of inanimate (water) and animated (vegetation) elements from the natural world.

The Blur Pavilion, erected at the EXPO 2002 in Yverdon-les-Bains, Switzerland, is an interesting design, which has an “unstable” form. The project, by Diller Scofidio studio + Renfro architects, assumed the use of artificial fog (which is a combination of two elements symbolic of air and water) as an element of one object’s aesthetic appeal. The project’s construction is a cable-bar tensegrity system with a set of nozzles that allow the formation of free and fleeting forms for the pavilion.

The use of water in shaping the object’s architectural expression was also visible in the Water Digital Pavilion project presented at the EXPO 2008 exhibition in Zaragoza, Spain. Architects from the Carlo Ratti Associati Studio designed a pavilion, the façade of which is a curtain of water controlled by a computer system. The water supply system was designed on the roof, placed on telescopic poles, so that the roof can change its position relative to the ground surface.

Thanks to the development of building technology, floral ornaments can be replaced by modern living plants that may form vertical gardens. The Caixa Forum in Madrid is an interesting example of a self-supporting, green wall located on the square. The Herzog & de

Meuron architectural project, realized in collaboration with Patrick Blanck, introduces a new element of ornamentation in shaping the architectural surface. The plants used as green walls make it possible to design a time-variant architectural elevation.

Inspiration by elements of the natural world is also evident in the development of architectural objects abstractly referring to forms found in nature. These design ideas that are a part of biomorphic architecture are visible in the shaping of exhibition pavilions and facilities related to culture.

The temporary Serpentine Gallery pavilion project, created in London in 2013 by the architect Sou Fujimoto, assumed integrating the forms into the landscape. The irregular structure of the building is light and transparent, and refers to the shape of clouds. The spatial rod structure that served as a support was modelled parametrically.

The Cultural Centre in Guangzhou, China is another example. Suiseki served as the inspiration in shaping the body of the building compositions, resembling natural landscapes laid with pebbles. The object's form was generated using digital tools. A structural triangular spatial mesh acts as the supporting structure of the pavilion.

Harpa Reykjavik Concert Hall and Conference Centre in Iceland presents similar analogies in the case of the irregularly structured surface, which refers to the shape of individual basalt boulders. The twelve-sided spatial modules constituting the structure of the facade are made of steel. This project, by Henning Larsen Architect, coupled with Olafur Eliasson's artistic involvement, assumed emphasizing the object's specific location by references to nature in its form and elevation.

In its search for natural world elements, contemporary architecture increasingly refers to nature, which is particularly evident in the design of curved forms representing a reference to the aesthetics found in nature in their rounded shapes and soft lines. The development of digital tools allowed for the design of curvilinear architecture using NURBS. Modelling of the organic shapes using Non-Uniform Rational B-Spline curves is done by changing the position of the control points.

The Kunsthaus project in Graz by architects Peter Cook and Colin Fournier is an example of shaping curvilinear architecture buildings. The soft form of the blob object gives a unique character to the building. Topological transformations were used in the project in order to search for optimal meshes in the organic spatial forms, enabling the creation of an optimal rod structure constituting the roof covering of the museum [13, p. 69–75].

A dynamic and organic effect was also obtained in the temporary Chanel Mobile Art pavilion project by Zaha Hadid Architects. The building was designed as a transformation of the torus referring to the golden spiral found in nature. The object's body was parametrically distorted according to the functional requirements. The building's design was made of steel sections divided into modules to enable mobility of the pavilion's complex form.

Another design trend in contemporary architecture is the use of natural world patterns and the transfer of biological processes, which is reflected in bionic architecture. An integral part of this project idea is to describe biological structures and processes by means of mathematical models that allow you to move the functioning of living organisms to technology, which is the goal of bionics.

Currently in architectural design we use mapping algorithms that mirror morphogenic processes which allow for a form's creation in terms of specific parameters, including environmental reasons. The Embryological House project by Greg Lynn is one of the first designs that uses these algorithms. During the computer simulation used in developing the form,

which Greg Lynn called animation as a way of form development, topologically inconsistent solutions were eliminated. As a result, the structure was built in a dynamic way. By transforming the original form with a Bézier curve, it became possible to raise curvilinear forms under complex transformations referred to as the topological manifold [13, p. 69–75].

Mathematical models describing natural shaping processes play a particularly important role in shaping structural bionic surfaces. The use of the models created in architecture enables the elimination of unnecessary geometry and the search for the optimal shape of the object. As a result, the form and structure of the building are designed in a synergistic manner.

The use of bionic mathematical models can be seen in the Research Pavilion project of 2011, created by architects from the Institute for Computational Design and Institute of Building Structures and Structural Design in Stuttgart. The form and structure of the building was designed using Voronoi diagrams that describe the structures, found in the wing of a dragonfly. The resulting forms are verified in terms of space and strength, taking into account the production capacity as well. The structure of the building has the characteristics of biological structures, i.e. diversity, anisotropy and hierarchy.

An equally interesting example is the design of the SUTD Library Pavilion on the Singapore University of Technology and Design campus, designed by the Form Lab City studio in collaboration with engineers from ARUP studio. Thanks to the arc-shaped chain based curves constituting the object's structure, it was possible to form the roofing without any intermediate supports. The construction of the pavilion roof covering was made with elements of plywood triangles joined by steel connectors.

Mathematical models are also used in pure classical geometrical forms, such as the Water Cube swimming pool in Beijing designed by PTW Architects. The construction of the rectangular body is made of a metal space frame based on the Wheaire-Phelan structure. As a result, an optimal dimensional structure was constructed. The use of digital tools in the project significantly influenced the parametric design of individual elements of the structure.

Shaping objects based on patterns found in nature is also reflected in the Federation Square project in Melbourne. The Lab Architecture Studio project assumed the use of aperiodic Pinwheel tiling with the characteristics of a fractal image in both structural elements and cladding divisions. As a result of using an algorithm, a free fractal structure was obtained.

### 3. Summary

The formation of modern structural surfaces defining the spatial form is increasingly becoming a play on finding a geometry that refers to the natural world. Depending on the design detail ideas, it has become possible to design optimal structures (bionic architecture), architectural concepts that are an abstract or commonplace reflection of forms inspired by nature (biomorphic architecture), architectural aesthetics modelled on curved shapes (“curvilinear” architecture), or simply using elements from the natural world. The architect decides which way the geometry will be played out. The result the designer wants to achieve is quite significant, which is: aesthetic quality, structural efficiency, organic quality of materials, or freedom of the spatial form. The design ideas inspired by nature strive for the excellence encountered in the natural world, which can become a token for the designer in the geometric play on Nature.

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