Peculiarities of Natural Technology Application in Architecture

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Abstract. Technical advancement of the modern world has made it possible to create unique artificial objects based on the natural technology principle. New engineering and design types, such as computational design, additive manufacturing, materials engineering, synthetic biology, etc. allow us to enter a new level of interaction between a human being and nature. This influences the formation of a new world view in the sphere of architecture and leads to the development of new methods and styles [1,2].

1. Introduction
Natural technologies are a new phenomenon, based on the observation of the objects of nature, understanding of the principle of their functioning and their transfer to the sphere of human activities. For example, designer Neri Oxman together with the Department of Materials Science and Engineering, MIT, Cambridge designed a new type of a zero-seam fabric imitating skin features (Figure 1): different density and strength depending on location on the body and its function (denser and stronger on the back, porous and thin on the face) without sharp boundaries, thus preserving object integrity due to soft changes of the material features [3,4].

Figure 1. Zero-seam fabric imitating skin features [3,5].

Observation of nature made it possible to make discoveries and create innovative solutions that can be applied in architecture. These are new types of construction systems, new building materials, new form-making principles [6]. Thus, the ICD ITKE specialists inspired by the spider behaviour designed a special mechanism that allows them to repeat its movements when it makes its nest from the web. It led to the creation of a unique pavilion (in terms of building principles and a form-making method) (Figure 2). Pneumatic formwork reinforced by carbon fiber from inside creates a light shell of the pavilion with unique
architectural features. The construction is based on biological building process with reinforced structures. This method is of acute interest for application in architecture, as it does not require complex formworks and can be adapted to different constructions. Application of carbon fiber and fluoroplastic membrane contributed to the formation of a robust but flexible construction that resembles skin. Adaptive computational design strategy was applied to create a form on the inner flexible shell [7].

![Figure 2. ICD ITKE Research Pavilion 2014 – 15 [7].](image)

Neri Oxman’s laboratory has designed a Silk Pavilion (Figure 3). Steel frame serves as a basis for fixation of a flat silkworm cocoon. Within a very short period of time, silkworms are able to create a structure of transparent silk web with sufficient strength and aesthetic appearance. Besides, such method of object construction does not lead to the death of insects. On the contrary, it contributes to their reproduction and further use without any harm [8-10].

![Figure 3. Silk pavilion [8].](image)

Harvard and MIT specialists designed a new construction material made of shrimp shells [11]. Applying 3D printing method and a robotically controlled extrusion system that allows creating the material with different properties while printing, the group of engineers developed a new environmentally friendly natural material that will not harm the environment after expiration of its service life. During 3D printing, crashed chitin is transformed into an integral seam-free construction representing a synthesis of a massive support and a delicate net (Figure 4). This is a multifunctional structure made of chitin with different properties. Such elements can be used in construction systems and separate elements of buildings, for filling of window openings, for furniture and interior design items, etc.

![Figure 4. 3D printing of the chitin-based material.](image)
Application of new material-processing technologies (such well-known materials as, for example, bamboo) is also very interesting. Before, these materials were considered to be nondurable due to the harm caused by the insects. Nowadays, there is a possibility to create unique objects made of these natural materials being today as durable and strong as steel or concrete. Impressive bamboo houses constructed by Elora Hardy and her team in Bali is its brightest example. This is a group of craftsmen, architects and designers who design bamboo houses and household items. They called themselves IBUKU, which means my mother nature. Their objects impress with structural complexity and shapes. There are no two identical bamboo stems, therefore, each house, bridge or room is totally unique. In her presentation, Elora Hardy talks about the potential of bamboo as ecological durable material and her inspiration source. However, in order to work with this material, it is necessary to follow certain rules, take weight and strength of the constructions into consideration, which extends the project period [12].

Bamboo tensile strength is equal to that of steel, while its compression strength resembles that of concrete. But bamboo is light as it is hollow inside. This is a wild fast growing (1 m per 3 months) hardy plant that can reach 20 m in height. It is very good at resisting earthquakes. It is an environmentally friendly material that will never run short.

Another innovative technological approach is based on application of materials engineering and synthetic biology for creation of different structures. While the former allows developing the behaviour of structures at high resolution, the latter enables designing and building novel biological functions by changing DNA. Such materials can be self-luminous, can convert carbon dioxide into oxygen, let the air in and preserve heat or cold whenever it is necessary. Designer Neri Oxman with her students create non-dividable architectural and design objects having common shape but characterized by different levels of density and elasticity (Fig.1) (skirts, arm-chairs, pavilions) [3,13,14].

Similar projects based on application of natural technologies and building and engineering innovations begin to appear in Russia as well. Workshop Spotcamp Yalta 2015 is one of such examples. This project is based on computational design technology with application of mobile modules with gas and thermostat. Tent system functions due to the ability of the gas to expand at heating. This allows creating shadow during summer days and compressing the structure to its minimal size when it is cold, gloomy or when the protection against direct sunlight is not required [15,16,17].

Figure 5. Spotcamp Yalta 2015 [15].

Natural technologies help us use green materials for construction, enhance their strength and create any form. This revolutionizes the existing methods of architectural engineering and provokes appearance of a new approach, a new style, i.e. bionic architecture.

Bionic architecture is often confused with architectural bionics, making these terms sound synonymous. But it is absolutely unacceptable, as architectural bionics is only one part of bionic architecture. This a new world view, a new architectural style based on principles of organization, structuralization and functioning of natural objects:

- Bionic form-making (architectural bionics).
- Bioclimatic form-making.
- Efficiency of resource use when building and operating buildings and constructions.
Natural technologies - assimilation of a living organism functioning in technologies.

- Intellectual control systems for buildings (Smart house).
- Reduction of harmful emissions.
- Health environment in buildings.
- Use of environmentally friendly materials.
- Optimization of a life cycle of a building.

Their combination allows putting into practice the ideas of sustainable development in the sphere of architecture, and all of them demonstrate environmental approach.

Natural technologies greatly influence the formation of this style, as they represent innovative techniques that were not available for an architect before [17]. Their implementation into the sphere of architecture allows solving a lot of aesthetic, construction, environmental and economic problems. However, little attention is paid to this issue in Russia: we can find certain form-making methods inspired by nature in the history of Russian architecture, but not more than that, though there is a potential for the development of this trend [18-20].

Natural technologies in architecture open new horizons in form-making, design engineering and building material industry. It is a new thought process aiming at an absolute reunion of nature and a human being. Its positive features include enhancement of aesthetic properties of the objects, environmentalization of architecture, and economic benefit from application of reproducible materials. As natural technologies are based on the idea of sustainable development, we can say that this trend in architecture is of current importance and has a good future.

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