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Biological Concrete - Material of the Future in the Aral Region

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Abstract: *The article will tell about the technology of concrete, the classification of concrete for construction will be given and important aspects of the production of concreting of construction structures will be indicated.*

Keywords: *aral sea, brutalis, concrete, bio-concrete, biomaterial, thermoregulator, pigmented microorganisms.*

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Modern architecture is the architecture of new technologies of building materials, changing traditional ideas about the physical nature of the properties of materials and their palette, the architecture of conceptual solutions, reflecting the formation of a new way of life and thinking of society.

In the construction industry, the past century is considered the century of rapid development of concrete production technologies and the study of its properties. The versatility of this material is a key factor in its application in construction. These are the structural, plastic and decorative properties of concrete, based both on the regularity of the physico-chemical process that leads a mixture of finely ground powders and water from the plastic mass into a stone-like state, and on the possibility of connecting concrete with other materials. For example, concrete reinforcement significantly increased the load-bearing capacity of the material, allowed changing the plasticity of walls and structures, created a new stylistic trend in architecture - brutalism (from the Latin word "brutalis" - rough, untreated), opened up opportunities for the great masters of architecture of the last century to implement the construction of unique buildings and structures.

Modern technologies are a step into the future, where the expansion of the range of concrete properties occurs due to the use of the features of the vital activity of bacteria and microorganisms. The vector of changing the properties of concrete is aimed at reducing the disadvantages of concrete that occur during operation, and at developing environmental concepts for the use of concrete in the so-called "green architecture", which opens up unlimited possibilities for designers, architects and designers. Materials obtained through biotechnologies have a high innovative potential in the

creation of new building materials, in particular biological concrete, and give significant advantages to this material compared to conventional concrete.

Concrete, as a building material, has many advantages, but there are also disadvantages. The main disadvantage of the material is that cracks and damage may occur as a result of operation, leading to a decrease in its structural qualities, requiring additional maintenance. There is also such a process as biological corrosion, which leads to the destruction of concrete, having a negative impact on the strength and decorative properties of the material, reducing its service life in the structures of buildings and structures. These problems are being solved by scientists and microbiologists when developing a new material – biological concrete. (Table 1).

Table 1 - Comparison of positive and negative qualities of conventional concrete and biological concrete

Properties of ordinary concrete		Properties of biological concrete	
positive	negative	positive	negative
Physical and mechanical properties. Availability of reserves of natural raw materials for production. Low energy costs for production.	The occurrence of cracks and damage. The costs of additional maintenance of buildings and structures during operation.	Improvements in structural stability. Strengthening of soils in earthquake-prone areas during the construction of buildings. Creating an environment for plant growth that supports the processes of natural air purification in Reducing the cost of electricity needed to ensure the functioning of the air conditioning system	Expensive production

Depending on the biomaterial used, several types of concrete are distinguished, each of which has its own characteristics: - bio-concrete based on Bacillus genus bacteria - bio-concrete based on Bacillus pasteurii bacteria -bio-concrete based on pigmented microorganisms.

Bio-concrete based on Bacillus genus can regenerate itself. The idea of creating such a building material was carried out by concrete researcher Eric Hagen and microbiologist Henk Jonkers (Netherlands Technical University in Delft). They found that when bacteria are added to concrete, the material is regenerated in the places of cracks. Bacillus genus bacteria, characterized by survivability and adaptability to any temperature conditions, were active when rainwater got into cracks, resulting in a chemical reaction between the components of the bacterium's vital activity (calcium lactate) and water, followed by the formation of limestone. It was he who filled all the microcracks. Today, self-healing concrete proves its effectiveness and relevance. The question of the implementation of this technology in the production of building materials remains open, and requires the active participation of not only scientists, technologists, but also architects.

Bio-concrete based on Bacillus pasteurii can strengthen the soil. It has already been mentioned above about the fragility of concrete, therefore, in situations where a concrete structure is experiencing serious loads, for example, during an earthquake, there is a risk of destruction of buildings and structures. To solve problems related to the sustainability of buildings, a group of scientists from the University of California, led by Professor Jason Deion, has developed a technology for strengthening the soil with the help of living microorganisms. According to the

conducted research, the bacterium Bacillus pasteuri, added to moist soil, promotes the adhesion of solid particles contained in it. As a result, calcium carbonate crystals are formed, it is this substance that is cement, which binds the particles of natural sandstone forming, in fact, building concrete – calcium carbonate crystals fill the gaps between the grains of sand and make them stick together. This technology is not afraid of landslides or earthquakes.

Bio-concrete based on pigmented microorganisms solves environmental problems. Faced with the growing threat of depletion of natural resources and the collapse of the global ecosystem, the human attitude to the environment is changing to some extent. Such construction materials are created and used in practice, which lead to the maximum reduction of human impact on the environment. A special role is given to modern landscape design, which is able to work wonders and bring a piece of natural beauty to the "stone jungle" of the metropolis, even in conditions when it seems completely impossible. An example of this is the creation of vertical gardens that easily take root on the facades of high-rise buildings. Various variants of vertical gardens and green facades are widely known in the world, and a number of similar projects have been successfully implemented. However, it is quite difficult to achieve sustainable growth from climbing plants, since they require certain conditions for this, which are not always feasible. A research group in the field of construction technologies of the Polytechnic University of Catalonia has developed concrete that supports and stimulates the growth of specific forms of vegetation directly on its surface.

Biological concrete based on pigmented microorganisms, unlike other systems, is an integral part of the structure. The material specially invented for building facades has environmental, thermal insulation and aesthetic advantages in comparison with other similar structural solutions. Simplicity and high speed of installation, no need for special maintenance and significant operating costs make this material competitive. One of the features of biological concrete based on pigmented microorganisms is its composition. It uses cement enriched with magnesium phosphate, which, due to the work of pigmented microorganisms, creates an acidic environment for the active development of mosses, microalgae and lichens, contributing to their natural growth (Table 2).

Table 2 – Technology of biological concrete production

Biomaterial / Initial data	Bacillus genus	Bacillus pasteurii	Pigmented microorganisms
Concrete + rainwater	Calcium lactate is formed, followed by transformation into limestone (self-healing bio-concrete)		
soil +		Calcium carbonate crystals are formed that bind natural sandstone particles (self-forming bioconcrete)	
Concrete + magnesium phosphate + water, precipitation			An acidic environment is formed, for the development and growth of lichen mosses (pigmented concrete)

On the basis of this bioconcrete, multilayer panels are produced, from which a system of vertical gardens is equipped. The natural accumulation of water inside the panels contributes to the creation of favorable conditions on the outer surface for the growth of protozoan plants. A unique feature of bioconcrete panels is that they do not allow plant microorganisms to grow uncontrollably. This plays an important role in maintaining the integrity of their root system.

The walls of buildings, in the construction of which this bioconcrete is used, quickly turn into vertical gardens.

The aesthetic value is that they can be used to decorate the facades of multi-storey buildings with real living paintings from plants, periodically changing colors and patterns. Moreover, the designs have an innovative approach to reducing energy costs to ensure the functioning of the air conditioning system, acting as a very effective temperature regulator, since plant formations form a kind of "fur coat" over time. The feasible contribution of panels from such bioconcrete in improving the ecology of the environment. Mosses do an excellent job of processing carbon dioxide, absorbing a considerable amount of carbon dioxide from the atmosphere, thereby supporting the processes of natural air purification in gassed megacities.

Undoubtedly, biological concrete, depending on the biomaterial used, is the material of the future. Biological concrete is just beginning its march on the construction sites of the world, solving the issues of constructive reliability of buildings and structures in extreme conditions and during operation, and the growing popularity of "green building" predicts a demand for a new material in the urban environment of the most developed countries.

The use of biological concrete in Belarus as a building material is not without relevance. The unique properties of bioconcrete do not depend on climatic conditions, which will extend the life of buildings and structures, expand the range of types of exterior finishes for buildings, create a new generation of architecture - the generation of biotechnology, creating an environmentally friendly and safe environment for human health.

Table 3 - Properties and application of concrete

Name of biological concrete	**Material Properties**	**Application**
Self-healing biological concrete	material recovery	in concrete building materials to improve structural stability
Self-forming biological concrete	material compaction	for strengthening soils in seismic zones during the construction of buildings
Pigmented biological concrete	creating an acidic environment in the material	creation of vertical green facades of buildings

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