FUNCTIONAL ACTIVITY IN THE COMPOSITION OF AN ADDITIVE TO BIO-CONCRETE

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Abstract. The work investigated bioadditives to concrete based on immobilized bacteria Bacillus licheniformis. Drying options and the state of microorganisms during immobilization affect their functional activity in the composition of the biological product. The addition of biological products with freeze-dried spores and cells immobilized on diatomite into the cement mixture significantly improves the strength characteristics of the cement stone.

Keywords: microorganisms, bioconcrete, biomineralizationb method.

INTRODUCTION

Currently, the idea of rational environmental management is becoming increasingly relevant, because The increase in consumption of the planet's resources by humanity leads to many environmental crises and climate change. Reducing the consumption of materials and increasing the service life of products, the production of which emits large amounts of greenhouse gases, are becoming absolute priorities in economic activity. A significant contribution to global man-made greenhouse gas emissions around the world is made by the production and use of concrete. The production of cement, the main component of concrete, produces 5% of anthropogenic carbon dioxide [1].

MATERIALS AND METHODS

It is impossible to refuse the use of concrete, since it is the most popular building material in the world, which is widely used in various structures due to its low cost and flexibility of properties depending on the additives used. Concrete structures can be cast in a variety of shapes and sizes, based on solving the required problems in the construction of certain buildings and infrastructure. Global concrete consumption is expected to rise to 3.7–4.4 billion tons by 2050 as the construction industry grows by 0.8–1.2% annually [2]. The need to develop new technologies to increase the service life of concrete structures is *recognized throughout the world. An additional beneficial effect on the environment from the introduction of new technologies will be a reduction in the development of new quarries for the extraction of gravel, limestone, etc.*

RESULTS AND DISCUSSION

The service life of concrete structures can be significantly extended by sealing cracks that appear in it over time, the formation of which leads to general cracking of the structure. In the future, the tightness is broken, which is why water can get inside and corrosion of the metal fittings can begin. This can be avoided if you use concrete with the addition of microorganisms, which over time can "heal" cracks that form in concrete structures during operation.

Microorganisms can also improve the properties of concrete even at the hardening stage due to accelerating the hardening process of cement paste, increasing the intensity of the formation of calcite and aragonite crystals, and reducing the proportion of air cavities that are replaced by minerals [3].

The search for microorganisms that are able to precipitate CaCO3, survive and reproduce at the alkaline pH of concrete, and also form spores that are resistant to unfavorable environments is a key task in the production of bioconcrete. These criteria are met by spore-forming bacteria of the genus Bacillus, which can survive at high pH, have high urease activity, and the ability to biomineralize [4].

Concrete with such characteristics is applicable in structures where it is difficult to regularly inspect the condition of concrete structures, as well as where repairing newly formed cracks is very difficult or practically impossible. These are, for example, underground tunnels, dams and other water structures, bridges and overpasses, high-rise buildings that require large quantities of high-quality concrete. In these cases, the use of concrete with improved strength characteristics, greater durability, and the ability to self-heal may be economically feasible.

During the study, microorganisms with high urease activity were isolated. Isolation was carried out on Christensen's medium of the following composition, g/l: NaCl – 5, urea – 20, KH2PO4 – 1.2, glucose – 1, peptone – 2, pH 6.6–6.8; distilled water. To obtain an indicator medium (assessment of urease activity), an aqueous solution of phenol red was added to a final concentration of 0.012 g/l.

The objects of the study were the bacteria Bacillus licheniformis, isolated from Lake Alykes (Greece) (Bl1) and Lake Pomorie (Bulgaria) (Bl2).

Further research was aimed at preparing a functional additive for concrete. Previous work has noted that different bacterial forms used in the bioadditive have different effects on the characteristics of the final cement paste. It was noted that preparations from cells of microorganisms that are just beginning to form spores can significantly improve the quality of cement compared to preparations from spores. In practice, immobilized forms of biological products are convenient. Immobilized forms are promising due to increased safety of cells/spores and ease of transportation of the drug. In the present study, diatomaceous earth was used for immobilization, which has good affinity for concrete and a high degree of sorption of bacterial cells.

The resulting biomass of microorganisms was immobilized on diatomite produced by Diatom Plant LLC to obtain the required concentration of cells in the preparation: diatomite was added to a concentrated suspension of cells/spores based on the culture liquid and thoroughly mixed, spores and cells were effectively adsorbed on the diatomite.

The resulting immobilized preparations were dried in different ways: some of them were dried at 37 oC in a layer 3-5 mm thick for 12-18 hours, and some were freeze-dried. Freeze drying of the samples was carried out using a CoolSafe 55-4 unit (ScanVak, Denmark). The samples were pre-frozen for 12 hours at a temperature of -70 oC, after which the system was evacuated (30 Pa). When drying, the following shelf heating modes were used: the shelves were not heated for 12 hours; For 6 hours the shelf temperature was maintained at 5 oC; 6 hours – 10 oC; 6 hours – 15 oC.

In the experiments, immobilized preparations with spores and cells at the stage of sporulation of Bacillus licheniformis bacteria (Bl1 and Bl2) were used with initial concentrations of microorganisms of 107 and 108 CFU/g of biological preparation, dried in a thin layer and freeze-dried.

CONCLUSION

The experiments show the potential of adding a biological product based on the bacteria Bacillus licheniformis to the cement mixture at the mixing stage. Experimental data showed that the use of microorganisms immobilized on diatomite increased the strength of cement stone by an average of 33% in bending and by 39% in compression compared to the control after seven days of hardening. An increase in the concentration of spores/cells in the biological product from 10^7 to 10^8 CFU/g did not lead to a significant increase in the strength properties of the cement stone.

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