Protection of Building Materials Against Biodeterioration Using Energy Saving Nanotechnology

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Summary. The advances in energy-efficient nanotechnologies in construction has been considered. The harmful effects of building materials, the impact of pollution in violation of indoor climate on human activity have been analyzed. The author has proposed a hypothesis that has been confirmed for using the method of concrete protection from biological damage.
Key words: nanotechnology, biological damage, concrete strength, indoor climate, life safety.

INTRODUCTION

High rates of urban development requires a recovery, "wellness" works for buildings conservation, with safe conditions for people's life, using effective ways of dealing with biodeterioration of building materials and structures. Energy saving nanotechnologies allow to solve these tasks.

Nanotechnologies are developing very rapidly in construction. From a present-day perspective nanoscience is the creation of nanomaterials and nanosystems, modification of objects that include components with size less than 100 nm in at least one dimension [9]. Energy saving nanotechnologies are aimed at creating more durable, affordable building materials of interest, taking into account the examined further problems.

THE MAIN PART

The European citizens spend more than 90% of their time in a confined space. More than 40% of people in enclosed spaces complain of the worsening state of health and various inconveniences (European Construction Technology Platform, 2005). Scientific studies have shown that the deformation process of nonmetallic building materials such as concrete, plaster, dry mixes of different origin is connected with the action of microorganisms. These structures damage is caused by the influence of microorganisms leading to a synergy of different types of corrosion.

Microbiological corrosion of concrete is found in residential and industrial buildings. The external manifestations of damage of building materials, products and designs by microorganisms are blistering, cracking, delamination of entire fragments of plaster, on the floor, ceiling and walls the presence of dark spots (Fig. 1, 2). Often these phenomena are accompanied by a variety of climatic conditions (high humidity, temperature extremes). Air pollution can cause respiratory and cardiovascular

Fig. 1. The microbiological corrosion in industrial building

Fig. 2. The microbiological corrosion in residential building

diseases, cancer, premature birth, increased infant mortality, neurological and psychiatric disorders, decreased immunity. 72% of residents of contaminated areas suffer from chronic bronchitis, diseases of the respiratory system. There is a clear link between air pollution and extensive myocardial infarction [9].

For prevention and creating a safe environment it is necessary to:

– reduce consumption of energy and material resources throughout the life cycle of buildings and structures, ranging from the manufacture of materials for buildings (based on strength increase) and materials biodegradation problems, site selection and further during design, construction and operation (creation of mircroclimate conditions, including in the working area of buildings and structures),

– expand and complement the classical building design with concepts of saving, serviceability, durability, impact on the environment and human health due to the resource saving (electricity, water and other resources usage taking into account progressive methods, including nanotechnologies as well),

– use innovative approaches, software (Autodesk, Graphisoft) effectively for various tasks, in particular, the calculation and optimization of the environmental buildings profiles already at the early stages of architectural design.

At residential, public and industrial buildings and structures, agricultural buildings, meat and dairy and livestock complexes the use in the operation of too high or low indoor temperatures, humidity, lighting, air quality (carbon dioxide, smoke, hazardous fine and coarse particles, dangerous radiation, microorganisms, etc.), noise, allergens, harmful gas, the improper disposal of waste water (Fig. 3), a solid or liquid waste have a detrimental effect. They are dangerous to human health and adversely affect the quality components in the operation of building materials [8, 15, 16].
The adverse effect on the human body is caused by a set of interactions between the material, environment and man, according to the dynamics of possible current state of relations "environment-man" [9, 11].

About 20% of the European citizens have an allergic reaction to the mites and lower fungi (caused by biodegradation of materials and structures, and others.). The dominance

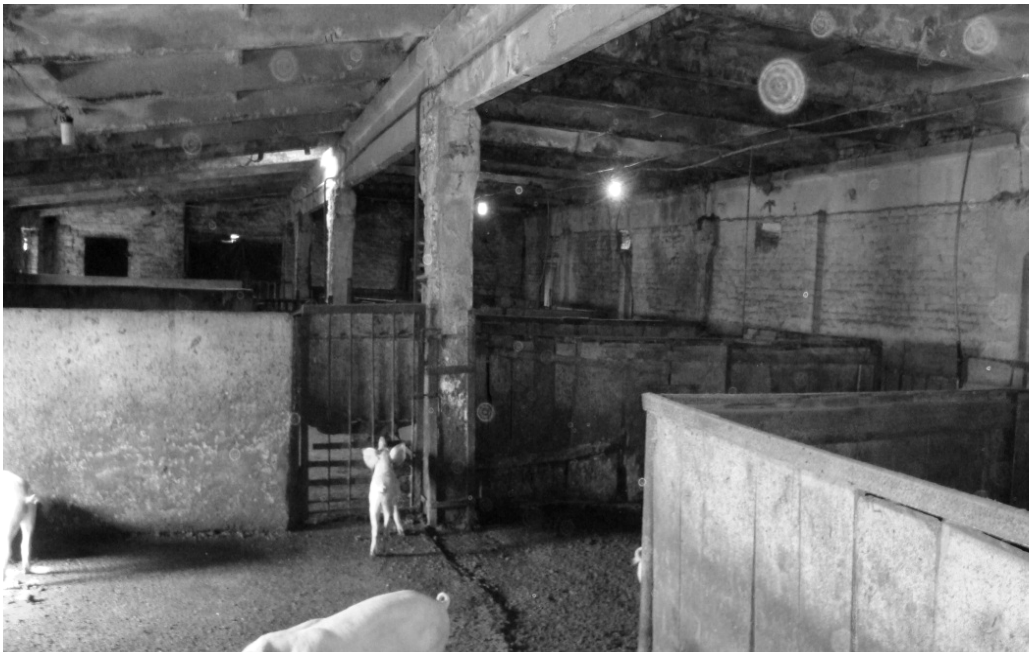

Fig. 3. Biological corrosion in animal farm

of asthma and allergies in residential buildings is also increasing [17, 18]. In Europe one of seven children suffers from asthma and in Western Europe the number of such children is ten times higher than in Eastern Europe (European Construction Technology Platform 2005). The main factors of concrete deterioration or corrosion are the environmental effect, aggressive atmosphere, changes of the indoor climate. At the same time the main threat to concrete is the same thing that contributes to concrete hardening – water and gas. Today it is accepted to distinguish several types of concrete corrosion depending on the characteristics of its triggering processes [7, 13, 10].

Chemical corrosion of concrete is most widely spread. Most often it is caused by the interaction of the surface layers of the concrete with atmospheric moisture and carbon dioxide contained in the air. Ensuring an effective response to biological corrosion of various building materials, products and structures caused by the vital activity on them or in them of various microbes and fungi [14], is becoming more and more acute scientific and practical problem in the field of construction and operation of residential and industrial buildings and structures (biological corrosion). Currently, more than 40…50% of the total number of recorded in the world injuries are related to the activity of micro-organisms [13].

In Kiev National University of Construction and Architecture various buildings, including recently renovated ones, have been examined for over 17 years. They have shown that 80…90% of buildings are struck by various organisms, bacteria, protozoa and other microscopic fungi, algae, lichens and even higher plants. Inside many buildings (hospitals, kindergartens, schools, institutions state) the pollution of the area with, for example, a variety of microscopic fungi (micromycetes) exceeds ten or over hundred times the maximum permissible limits, if you focus on the regulations of the European Union. Microscopic fungi tend to degrade the performance of construction materials, on which they grow, causing the biological damage and biodegradation of the latter. They can cause mycetogenic allergy, mycoses, mycotoxicosis and other diseases. Everything is connected with high risk to human health and life in general [8, 9, 12].

The possibility of concrete corrosion is determined by its initial porous structure and the presence in it of so-called capillaries on which the moisture and other substances can penetrate into concrete causing destructive processes. Therefore, the main task to prevent or stop concrete corrosion is to protect its pores from potentially harmful elements. This can be done at various stages, including using nanotechnologies.

Measures of protection against corrosion can be divided: passive and active. Passive protection measures are intended to protect concrete from the damaging effects of harmful carriers (application of coatings and leveling compounds, synthetic lining films and plates, the use of energy-efficient nanotechnologies (magnetic water) to increase concrete strength and biological stability during production) [13]. Special protective additives for water resistance and high density concrete structure may also be included in its composition at the time of manufacture. The technology of concrete manufacture may include the addition of special protective layers, providing it with additional protection, and after its manufacture processing its surface with special hydraulic, vapor and gas barrier compositions, applying the protective coating (membrane) by sputtering products against bacteria, mold and other microorganisms. The goal of active protection measures is to minimize the conditions leading to the formation of harmful carriers (compliance with indoor climate requirements (ventilation, drying, waterproofing buildings, monoblock devices out letting condensate, mechanical cleaning and etc.).

Active researches on the use of various nanomodifiers in the production of concrete are of much interest for developers. The obtained results show a significant increase in consumer characteristics, such as strength,

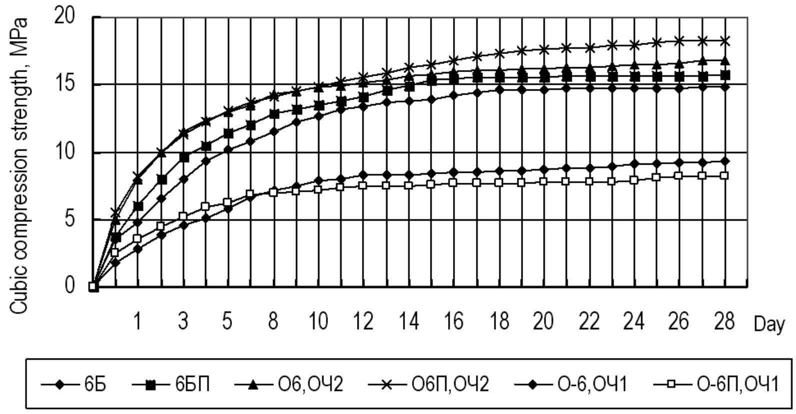

Fig. 4. The dependence of the strength of concrete samples series "6" on time:
Series "6" W/C = 0.76; 6БП, 6Б – samples prepared by classical technology, respectively using steaming and without it; 6ОП, ОЧ1; 6ОП, ОЧ2; 6О, ОЧ1; 6О, ОЧ2 – samples prepared using magnetic water respectively using steaming and without it; ОЧ1, ОЧ2 – installation modes with different characteristics

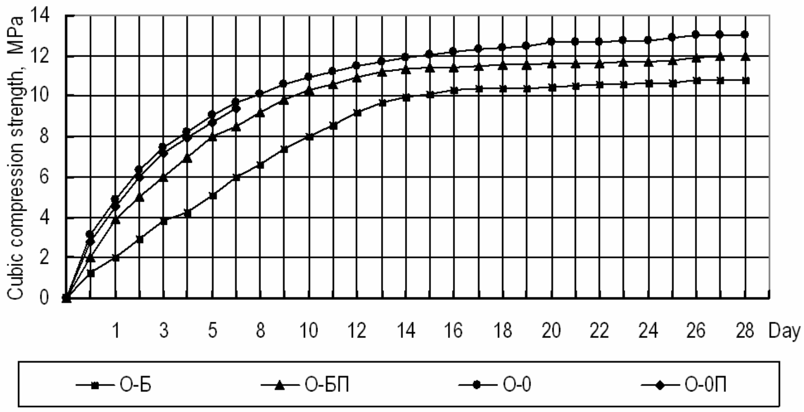

Fig. 5. Dependence of the strength of concrete samples Series "O" on time:
Series - "O", W/C = 0,77 (with a broken structure of cement); ОЧ2 – setting mode; О-БП;
О-Б – samples prepared by classical technology, respectively, using steaming and without it; О-0П; О-0 - samples prepared using magnetic water, respectively, using steaming and without it

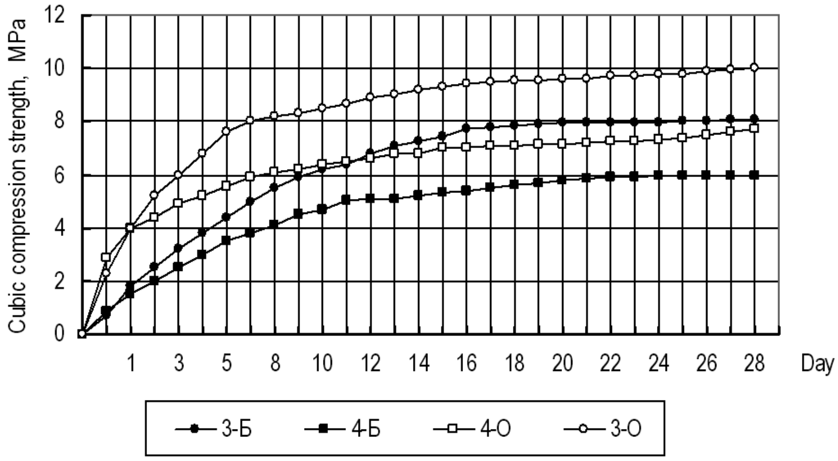

Fig. 6. Dependence of the strength of concrete samples Series "3" and "4" on time:
Series - "3", W/C = 0,66; 3-Б – samples prepared by classical technology; 3-0 – samples prepared using magnetic water (ОЧ2 – setting mode), Series - "4", W/C = 0,74 (with addition of bischofite 0,14%); 3-Б – samples prepared by classical technology; 3-0 – samples prepared using magnetic water (ОЧ2 – setting mode)

from 10…20%, fracture resistance of concrete blocks energy to fracture, its hardening acceleration (Fig. 4, 5, 6). Energy saving nanotechnologies help considerably save energy resources, reducing the time spent on grinding clinker [9].

Currently the technology based on the practical implementation of biocidal materials (Kimry city) is quite widely applied. Our energy-efficient nanotechnologies thanks to the ultra small particle size reach the high strength and resistance of the coating to external influences to maintain the indoor climate. On the basis of biochemical method the technology of synthesis of silver nanoparticles with a broad spectrum of antimicrobial action, etc. has been created.

The kinetics, mechanism and nature of materials hardening are complicated and the action of magnetic water treatment is shown not only in the process of samples setting and strength development, but also in the quality of obtained products [19]. According to industrial tests, the strength of concrete and other building materials has growing by 10…30% (We take into account this fact in recommendations for biodeterioration mitigation of building materials, products and structures during their operation). It becomes possible to reduce the consumption of cement and water during manufacture [20].

1962, the USSR, B.A. Neiman – the beginning of magnetic water application in the production of concrete in construction. Now magnetic water is used by the leading manufactures of concrete, cement, plaster, tiles using gypsum binders.

The effectiveness of water treatment by the magnetic field, starting from the first devices of the Belgian company EPURO brand Cepi, is determined largely by the magnetic field intensity in the gap, water velocity, the angle between the water directions and the magnetic field lines, and the number of intersections and the contact time of water with magnetic field.

It is described in literature that the initial use of magnetic water contributes to the intensity of the components interaction, which leads to the reduction of the manufacturing processes and increase in the products strength [3]. Since the process with ordinary water can be insufficiently effective, our goal is to develop technologies to activate this process by the method of using magnetic water.

According to current scientific hypotheses [1, 2, 3, 4, 14], the magnetic field affects the water molecules. There is a spin flip of protons of these molecules' nuclei with the release of the molecular energy. This leads to water clusters destruction and turns magnetic water into liquid with unbalanced H2O molecules that tend to interact with other active substances. Due to the small size of the monomolecules, this leads to a strong speed growth of diffusion processes of such water transfer, including in ultramicropores capillary-porous bodies, in which ordinary water can not penetrate.

The hypothesis about nanotechnologies is used by the author to solve the problem of concrete biodeterioration as a capillary-porous body. For this a series of experiments have been conducted and 150 samples of cubes have been analyzed.

The author investigated and presented (Fig. 4, 5, 6), the samples with dimensions 70x70x70, series "6", "O", "3", "4". The magnetic water was prepared during the tap water flow through the pipeline using magnets "Ilios-M", company "Votali", Donetsk. The filed characteristics were 230...430 mT operating at setting mode: cleaning – 1, 2 (ОЧ1, ОЧ2 – with different service programs).

Samples in the forms of cubes were prepared in batches (with or without steaming (up to 28 days.) The steaming chamber was used for steaming (t = 80°C, τ = 6 h).

The determination of the samples compression breaking strength was performed on the press in accordance with current standards.

On the 7...11th day samples prepared with the magnetic water (characterized by decreased pore structure uniformly distributed in the material) gain strength while the samples with ordinary water – on the 28th day. On the 7th date the strength of the samples prepared with the magnetic water is 20…40% more than the strength of samples prepared with ordinary water. The samples prepared with the use of magnetic water on the 14th day gain strength equal to the strength of the samples with steaming with ordinary water on the 28th day. On the 28th day the strength of the samples prepared with magnetic water is 7 ... 12% more than that of the samples prepared with plain water. Further series of experiments on the physico-chemical characteristics of concrete are planned.

CONCLUSIONS

Our studies confirm the practicability of the magnetic water use as an activator in the production of construction materials, which will let use energy-efficient nanotechnologies in the production. This requires a deep study of complex physical and chemical systems, which is scheduled by the author in the following series of experiments.

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ЗАЩИТА СТРОИТЕЛЬНЫХ МАТЕРИАЛОВ ОТ БИОПОВРЕЖДЕНИЙ С ИСПОЛЬЗОВАНИЕМ ЭНЕРГОСБЕРЕГАЮЩИХ НАНОТЕХНОЛОГИЙ

Аннотация. Рассмотрены достижения энергосберегающих нанотехнологий в строительстве. Проанализированы вредные воздействия строительных материалов, влияние биологического загрязнения вследствие потенциально возможного биологического обрастания на жизнедеятельность человека. Автором предложена гипотеза, которая нашла подтверждение для использования метода защиты бетона от биоповреждений.

Ключевые слова: энергосберегающие нанотехнологии, биологическое обрастание, прочность бетона, биологические загрязнения, безопасность жизнедеятельности.