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THE PROTECTION OF WOODEN CONSTRUCTING MATERIALS AND STRUCTURAL ELEMENTS OF BUILDINGS AGAINST BIOLOGICAL DAMAGE

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Abstract. The methods of wooden building materials protection from biological damage were analysed. Constant technical monitoring is the main preventive measure against damage of structural elements of the wooden buildings. The most effective methods from biological damage are chemical treatment, capillary infiltration, diffusion treatment and impregnation under pressure. The essence of action against mycodestructors is to create conditions for the preservation of wood buildings by removing danger factors: moisture more than 20 %, condensation phenomena, sharp fluctuations in temperature, freezing, stagnant air, etc. Effective preventive bioprotection methods are based on the ability of organisms to inhibition or complete growth termination of some species in the presence of the others. It was also found that for the preservation of historical-architectural buildings it is appropriate to apply diffusion method using boron compounds that are able to penetrate into the depth of the construction, while providing maximum protection with minimum interference into materials.

Key words: wood, building materials, historical and architectural building, protection, biological damage, mycological damage.

1. Inroduction

Building designs can significantly change our environment, both in positive and in negative direction. During construction process the environment is polluted and natural resources are spent. However, energy-efficient and economical buildings not only provide comfortable operation and ecosafety of the construction process, but also minimize environmental impact. When choosing building materials all stages of their life cycle should be considered – from production and construction to maintaining and recycling [1]. Materials should satisfy such criteria as comfort, efficient energy consumption, healthy living conditions and environmental protection [2]. Wood is one of the best natural materials that is being widely used in construction from ancient times to the present days. This is explained by its availability and aggregate extraordinary technological properties: low thermal conductivity, large tensile strength and compression, small density, ease of machining, energy efficiency, economy and good appearance. However, despite a number of positive qualities, wood as a building material has some limitations: the heterogeneity of structure, water absorption, flammability, ability to rot and biological damage.

2. Problem formulation

Biological destruction of industrial wood is mainly caused by the organisms that come into contact with the surface and as a result of active life, change the characteristics of the material. Micromycetes belonging to the genera *Fusarium, Trichoderma, Aspergillus, Penicillium, Cladosporium, Scopulariopsis, Alternaria, Geotrichum, Paecilomyces* cause a considerable destructive effect on building objects. Abiotic environmental factors such as humidity, temperature, light; medium acidity, oxygen levels in the air, etc. affect the growth and physiological activity of micromycetes. High humidity caused by intense rainfall, technical flaws of designs etc. are the main factors of mycological destructions of building structures. Fungi

begin to grow when the humidity of the environment is approximately 75 %. It is believed that indoor conditions in which there is a lack of natural ventilation and lighting is particularly favourable for the life of these organisms.

It should be noted that microorganisms, colonizing the surface of building materials and structures, not only provoke their vital functions a destructive effect, but also lead to serious violations of the environmental situation inside the buildings: occurrence of unpleasant mold smell, dissemination of spores, formation of toxic substances, allergens that can cause diseases in humans (fungal infections, asthma, etc.) [3–5]. It is therefore necessary primarily by any means to prevent the emergence of mycological damages of wooden structures. In this context, the aim of this study is to analyse the remedies of wooden building materials and constructive elements of buildings from the effects of biological factors.

3. Results and discussion

3.1. Constructive measures to protect the wooden building materials and structures from biological damage

Fungi damage of wood can occur as a result of the transfer of spores from the environment (air currents or ground cover) or remains of the affected timber. Therefore, the fight against mycological destructors should begin from the receipt of the wood. When receiving timber is subject to careful inspection and if suspicions arise, it is immediately withdrawn and put aside. Logs and lumber should have a healthy color of wood and have no traces of mold. Storage of wooden materials in warehouses is also an important factor in the quality of construction materials that will be delivered to the construction site. Thus, the site for making wood material, regardless of the duration of storage, should be located in high, dry, ventilated area and cleaned from litter and vegetation [6].

To prevent damage to wood in the buildings in operation, structural prevention is applied during the construction phase,. This method of wood protection is based on the principles of creating and maintaining moisture and temperature conditions that rule out the possibility of living of fungal organisms [7]. Constructive measures in the construction of buildings and structures should include:

1) protection of wooden structures from direct humidification precipitation, ground water, industrial water and melt;

2) protection of wooden structures from freezing, capillary condensation and moistening;

3) continuous drying of wooden structures by ventilation of the room, placement of ventilation paths in the structures and parts of the buildings;

4) requirements for fire protection of wooden structures in accordance with applicable regulation [8].

Thus, the essence of all constructive measures against mycodestruction is to create the necessary conditions for preservation and maximum extend of the life of wood in the construction of buildings [6].

3.2. Protection of the operated buildings

In order to prevent mycodamage of wooden constructions in buildings that were put into operation, constant monitoring of technical constructive elements and periodic evaluation of the exploited buildings must be conducted annually. Such preventive measures are effective in their compulsory execution and in tandem with the operational reconstructive actions if necessary.

The fight against wood-destroying fungi in operated buildings is conducted by relevant experts. In case of identifying the damage of wooden structures in buildings and public housing a specialist should be immediately called to establish the causes and size of damage of structures or buildings in general. The expert takes samples of the damaged wood, which are directed to the laboratory for the research. Samples are taken separately to determine the moisture of wood, the fungus-destroyer and the viability of the fungi. Depending on the size and extent of the damage to the structures it is necessary to carry out major repairs of the buildings or emergency localization of separate damage sites in order to prevent further spread of mycological agents and possible accidents [6].

3.3. Chemical treatment of wood as a method of protecting wooden structural elements of buildings and structures from biological destruction

The choice of preservative compositions and methods of chemical treatment of wooden elements of buildings and structures should be made considering: 1) the humidity of wood; 2) the conditions of the construction and assembly work; 3) operating mode of buildings and structures; 4) production conditions of antiseptics in enterprises of the construction industry. For example, water antiseptics are used for impregnation of structures that are protected from moisture and leaching of precipitation, and oil antiseptics and pasta - for impregnation of elements of the buildings that are in operation outdoors [4]. Methods of chemical processing, depending on the physical phenomena underlying the process, may be divided into 3 groups: capillary impregnation, diffusive impregnation and impregnation under pressure [7].

Impregnation of wood by oily and water-soluble preservatives is performed under pressure in autoclaves. The humidity of the treated wood herewith should not exceed 30 % [9]. The depth of penetration of the preservative is determined by change of wood colour.

Impregnation of wood in hot-cold bath is performed both by water-soluble and oily antiseptics, so initially the parts are immersed into a bath with hot antiseptic and kept in it, and then into a bath with cold antiseptic. Temperature drop and dilution in the internal pores of the wood contribute to the absorption of antiseptic. Temperature of hot baths for water antiseptics should be 95–98 °C, cold – 15–20 °C and for oil antiseptics -90 °C and 40–60 °C respectively. Moisture content should not exceed 30 % for impregnation of wood with water soluble preservatives and not more than 25 % with oily protective substances [9]. The dipping of the parts into the baths is carried out in special containers, wherein the details are placed in rows on the gaskets of the same kind and the same section. The amount of antiseptic, which is absorbed by the wood, depends on the thickness of the sapwood that is impregnated to the entire depth. Nuclear part of ripe wood leaks to a depth not more than 3 cm.

Impregnation of wood in high temperature baths is used to protect raw sleepers, bridge beams, bars of cooling tower, etc. Impregnating in hot baths with antiseptic is used for timber with thickness up to 25 mm and is held as oil and water solutions at + 90–95 °C. Impregnation in cold baths with water antiseptics is used for timber with thickness up to 25–40 mm.

The main methods of diffusion impregnation are the application of pastes, bandage treatment and impregnation by excerpts of wood in concentrated solutions of salts. Diffusion impregnation is based on the diffusion of molecules or ions which are impregnating substance into raw timber from its surface [5].

Ways of capillary impregnation include: impregnation applying the solution to the surface of the wood, impregnation by immersion into baths and panel impregnation. Surface conservation is carried out with high concentration of preservatives using atomizer twice with an interval of 2–4 hours; it can also be performed by immersion into a bath with a small term of exposure or by applying a solution with a brush. Under the action of capillary forces a certain amount of the solution is held on the wood surface, a part of which then penetrates to some depth. Panel impregnation is used for protective treatment of wooden buildings without their dismantling by installation of special panels on the surface [6, 7].

3.4. Biological methods of protection

Effective, but not common, methods of preventing biological damage may include the means based on the competitive relationships between organisms. The basis of these methods is the ability of organisms to inhibition or complete cessation of growth of some species in the presence of the others, that is the principle of antagonism. Inhibition often occurs due to the accumulation of a large number of metabolic products of certain organisms that are toxic to other members of the population. This antagonistic activity is caused mainly by the influence of secondary metabolism products – antibiotics.

The phenomenon of antagonism between populations of microorganisms can be used to inhibit fungal microorganisms in soil, where the construction is planned. For this, construction site is pre-poured by water suspension with specially selected actinomycetes followed by controlling of the number of microorganisms species that are sensitive to antagonists. Similarly, we can apply the competitive bacteria to protect building structures from mycological corrosion (selecting those that do not cause biodeterioration). It should be noted that these processes are characterized by reliability and prolongation of validity but not sufficiently investigated for the implementation of this method in construction on a permanent basis [3, 10].

4. Protection of wooden elements of historical and architectural buildings from the influence of biological agents

The very first and most important method of protecting the historical and architectural wood from biodestruction is to keep structures from excessive moisture. Since living organisms need water for life activity, which results in destruction, protection is provided just by keeping the original design dry. However, in the temperate climate of the northern hemisphere this simple task is often difficult to reach. Control of moisture in wooden structures involves a systematic approach that provides for protection against the infiltration of ground water, rain, water supply leakage, sewerage, formation of condensation.

If it is impossible to avoid moistening of wood, preventive conservation methods are used to provide long-term protection. Such methods include processing of paint and varnish products to extend the life of wood, which is not in contact with the ground, but is exposed to the external environment, and processing of wood products with preservatives, including processing under pressure and diffusion method.

The main reasons for wood treatment outside are protection against degradation by reducing atmospheric influences (UV light, precipitation, etc.) and improving the appearance of the treated wood surface. Wood finishes are divided into two main categories: 1) the

opaque coatings (paints and solid colorants); 2) “natural” coating, such as water repellent, water repellent preservatives, oils and semi-penetrating dyes.

There is a great diversity of chemicals available for treatment of wood to provide varying degrees of resistance to insects and fungal organisms. Wood protection by chemicals is achieved in three main ways: impregnation under pressure, local application (soaking and applying with a brush) and treatment of diffuse preservatives that can migrate by diffusion across a piece of wood. The third type of chemical treatment involves the use of boron compounds and is of interest for use in preserving historic buildings.

The wood can be treated with borate under pressure, but a diffusion method is more effective for historic preservation, herewith protective product is applied using the method of spraying or dipping. Because of their unique properties borate preservatives are able to diffuse from the surface into the depth of a piece of wood providing a maximum protection with minimum interference into the structure of historical and architectural structures [11–13].

5. Conclusions

1. The essence of all constructive acts against mycodestruction is to create the necessary conditions to preserve and maximize the duration of wood in the construction of buildings by removing such factors as moistening more than 20 %, condensation phenomena, acute fluctuations of temperature, freezing, stagnant air and so on.

2. Preventive measures for mycodamages of wooden structures in maintained buildings are constant technical monitoring of the structural elements and periodic review of the exploited buildings annually.

3. One of the most effective methods to protect wooden structures from biological damage is chemical processing methods of capillary infiltration, diffusion impregnation and impregnation under pressure.

4. The uncommon methods to prevent biological damage include methods based on the ability of organisms to inhibition or complete growth termination of some species in the presence of the others that is the principle of antagonism.

5. A diffusion method is effective for historical preservation when boron compounds able to penetrate into the depth of the construction are used, while providing maximum protection with minimum interference into the structure of the historical and architectural construction.

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