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MOISTURE CONTROL TECHNIQUES FOR BUILDING COVERING SYSTEMS EXPOSED TO ATMOSPHERIC PRECIPITATION

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Abstract

Moisture penetration caused by atmospheric precipitation significantly affects the durability and service performance of building covering systems. Water ingress into capillary-porous construction materials accelerates corrosion processes, freeze–thaw degradation, and biological deterioration, leading to premature failure of structural elements. This research presents an engineering analysis of moisture control techniques for building coverings, including hydrophobic additives, surface hydrophobization, drainage systems, and nanomodified materials. Experimental and field data reported in previous studies are analyzed to evaluate their effectiveness in reducing water absorption and improving durability characteristics. The results demonstrate that hydrophobic treatments can reduce water absorption by up to 80%, while properly designed drainage systems decrease moisture accumulation by 60-75%. Nanomodified materials provide additional improvements in long-term moisture resistance. The study confirms that integrated moisture control strategies offer the highest performance and are suitable for practical engineering applications in modern construction.

Keywords

Building coverings, moisture control, hydrophobic materials, drainage systems, nanotechnology, durability.

1. Introduction.

Building covering systems are continuously exposed to atmospheric precipitation, which represents one of the primary sources of moisture ingress into construction materials. Penetration of water into capillary-porous structures such as concrete, masonry, and plaster leads to deterioration of mechanical properties, corrosion of reinforcement, freeze-thaw damage, and biological growth. These processes significantly reduce the service life and reliability of buildings and structures.

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Recent climatic changes, characterized by increased precipitation intensity, have further intensified moisture-related problems in construction practice. As a result, the development and implementation of effective moisture control techniques have become a critical engineering task (see Fig. 1) [1, 2, 3, 12].

This article investigates modern engineering approaches aimed at reducing moisture penetration in building covering systems. The focus is placed on hydrophobic additives, surface hydrophobization technologies, drainage systems, and nanomodified materials.

Fig. 1. Damage to the wall and roof slab as a result of the structure getting wet.

The following are considered the main contributions of this study:

1. Systematization of engineering moisture control techniques applicable to building coverings;
2. Comparative analysis of their effectiveness based on experimental and field data;
3. Justification of integrated moisture protection strategies for practical engineering applications.

2. Materials and methods.

2.1. Hydrophobic additives.

Hydrophobic additives are chemical modifiers introduced into construction materials to reduce capillary water absorption. These additives include organosilicon compounds, polymer modifiers, paraffin emulsions, and fatty acid salts. Their mechanism of action is based on blocking capillary pores or reducing surface energy, thereby preventing water penetration [4, 10].

Studies indicate that incorporating hydrophobic additives into concrete and masonry materials can reduce water absorption by 50-80%, while simultaneously improving frost resistance and durability under aggressive environmental conditions.

2.2. Drainage systems.

Drainage systems are widely used engineering solutions designed to remove surface and infiltrated water from building coverings. Properly designed drainage channels and stormwater systems prevent moisture accumulation and reduce hydrostatic pressure on covering layers [5, 9].

Field investigations demonstrate that efficient drainage systems can reduce moisture accumulation in structural elements by 60-75%, provided that design and installation requirements are strictly followed.

2.3. Surface hydrophobization.

Surface hydrophobization involves treating building materials with water-repellent compositions, primarily based on organosilicon compounds. These treatments form a thin hydrophobic layer that inhibits water penetration while maintaining vapor permeability [6].

Hydrophobized surfaces have been shown to retain their protective properties 30-50% longer under high-humidity conditions compared to untreated materials.

2.4. Nanomodified materials.

Nanotechnology-based solutions represent a promising direction in moisture protection. The incorporation of nanoparticles such as titanium dioxide (TiO_2) and silicon dioxide (SiO_2) into construction materials leads to pore structure densification and improved moisture resistance.

Experimental data indicate that nanomodified materials can reduce water penetration by up to 60% and provide enhanced long-term durability compared to conventional materials.

3. Results and discussion.

Comparative analysis of the reviewed methods demonstrates that each moisture control technique provides specific advantages. Hydrophobic additives are highly effective in reducing water absorption at the material level, while surface hydrophobization offers additional protection for exposed elements.

Drainage systems play a critical role in preventing moisture accumulation and are particularly effective when combined with hydrophobic treatments. Nanomodified materials enhance long-term performance by improving microstructural properties and resistance to environmental degradation.

The results confirm that **integrated moisture control strategies**, combining material modification and structural solutions, provide the highest level of protection for building covering systems.

4. Conclusion.

This research analyzed engineering techniques for controlling moisture penetration in building covering systems exposed to atmospheric precipitation. Hydrophobic additives, surface hydrophobization, drainage systems, and nanomodified materials were evaluated in terms of effectiveness and applicability. The findings indicate that integrated moisture control approaches significantly reduce water absorption and improve durability characteristics. These solutions are recommended for practical implementation in modern construction to enhance the service life and reliability of building coverings.

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