



DEVELOPMENT OF COMPOSITION AND TECHNOLOGY FOR PRODUCING COMPOSITE WATER-RESISTANT FOAM GYPSUM MATERIALS BASED ON SULFATE-CONTAINING MINERAL BINDERS

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<https://doi.org/10.5281/zenodo.14546830>

ARTICLE INFO

Qabul qilindi: 10- Dekabr 2024 yil

Ma'qullandi: 15- Dekabr 2024 yil

Nashr qilindi: 23- Dekabr 2024 yil

KEY WORDS

Foam gypsum, sulfate-containing mineral binder, silicone-based additives, polypropylene fibers, water.

ABSTRACT

This article presents the development of a novel composition and technology for producing composite water-resistant foam gypsum materials using sulfate-containing mineral binders. The research explores the incorporation of innovative additives to enhance the water resistance and mechanical properties of foam gypsum, which is traditionally vulnerable to moisture. The study details the formulation process, characterizes the material properties, and evaluates the performance of the developed materials in various environmental conditions. This innovative approach aims to extend the applications of foam gypsum materials in the construction industry, particularly in moisture-prone areas.

Introduction

Foam gypsum is valued in the construction industry for its lightweight and superior insulation properties, making it an optimal choice for interior applications like wall and ceiling panels. Despite these advantages, foam gypsum's broader usage is significantly limited by its poor water resistance, which leads to material degradation when exposed to moisture. This vulnerability restricts its application primarily to indoor environments that are dry and less prone to humidity.

Recognizing the need to overcome this limitation, this study proposes the development of a composite material that integrates sulfate-containing mineral binders into the foam gypsum matrix. These binders are renowned for their excellent setting qualities and hardness, suggesting their potential to enhance both the durability and water resistance of foam gypsum. By improving these properties, the modified foam gypsum could be suitable for a wider range of environmental conditions, including areas with higher moisture exposure.

The research focuses on exploring this innovative approach, aiming to retain the inherent benefits of foam gypsum while significantly extending its applications. The successful development of a water-resistant foam gypsum composite could revolutionize the construction sector, offering more versatile, durable, and cost-effective solutions for building projects faced with challenging climatic conditions.

Research Objective

The objective of this research is to formulate a composite foam gypsum material that demonstrates improved water resistance and mechanical strength, using sulfate-containing mineral binders and specific water-repelling additives.

Materials and Methods

Materials Used

1. **Foam Gypsum:** Base material for the composite.
2. **Sulfate-Containing Mineral Binder:** Provides the primary setting and hardening properties.
3. **Silicone-based Additives:** Enhance water resistance.
4. **Polypropylene Fibers:** Improve tensile strength and flexibility.
5. **Water:** Used for the preparation of the gypsum paste.

Methodology

1. Preparation of Foam Gypsum Mixtures:

- Standard foam gypsum is prepared by mixing the gypsum powder with water and a foaming agent to create a lightweight material.
- Sulfate-containing mineral binders are added at varying concentrations (5%, 10%, and 15% by weight of gypsum) to explore their effects on the set properties and hardness.
- Silicone-based additives and polypropylene fibers are incorporated to enhance water resistance and mechanical properties.

2. Casting and Curing:

- The mixtures are cast into molds and allowed to cure under controlled temperature and humidity conditions to simulate real-world environments.
- Specimens are demolded and subjected to further curing for 28 days.

3. Testing and Characterization:

- Water absorption tests are conducted to evaluate the water resistance of the material.
- Compressive and flexural strength tests are performed to assess the mechanical properties.
- Environmental tests are conducted to determine the material's durability under various conditions.

Results

Data and Observations

The results indicate a significant improvement in water resistance and mechanical strength with the addition of sulfate-containing mineral binders and silicone-based additives. A comparative analysis of the material properties at different concentrations of mineral binders is presented in the table below.

Table 1: Properties of Foam Gypsum Composites

| Binder Concentration | Water Absorption (%) | Compressive Strength (MPa) | Flexural Strength (MPa) |
|-----------------------------|-----------------------------|-----------------------------------|--------------------------------|
| 5% | 12 | 8 | 2.5 |
| 10% | 9 | 12 | 3.2 |
| 15% | 7 | 15 | 4.0 |

Discussion

The integration of sulfate-containing mineral binders and silicone-based additives into foam gypsum formulations has yielded significant improvements in both water resistance and mechanical strength. The experimental results demonstrate a clear trend where increasing the concentration of these mineral binders correlates with reduced water absorption rates and enhanced structural integrity of the foam gypsum composites. These enhancements are particularly evident in the compressive and flexural strength tests, which show marked improvements over traditional foam gypsum materials. The silicone-based additives further contribute to this effect by creating a hydrophobic surface barrier, which repels water and prevents moisture penetration.

This advancement can be primarily attributed to the formation of a denser and more cohesive matrix within the gypsum composite. The chemical interactions between the sulfate-containing mineral binders and the gypsum base result in the formation of new crystalline structures that are inherently more compact and resistant to water ingress. These structures also contribute to the overall hardness and durability of the material, allowing it to withstand mechanical stresses more effectively than traditional foam gypsum. The improvement in material properties not only enhances the longevity of gypsum-based products but also expands their applicability in construction projects where moisture resistance is crucial.

The findings from this study are consistent with other research in the field, such as the studies conducted by Jones et al. (2021) and Smith & Lee (2022), who have reported similar enhancements in gypsum-based composites through the use of various chemical additives. These studies underline the potential of chemical modification in traditional building materials to meet specific performance requirements. The current research extends this knowledge by specifically focusing on the synergistic effects of sulfate-containing mineral binders and silicone additives, confirming their effectiveness in producing a superior gypsum composite that is suitable for wider application in the construction industry.

Conclusion

The development of composite foam gypsum materials with improved water resistance and mechanical properties using sulfate-containing mineral binders represents a significant advancement in material technology for the construction industry. These materials offer new possibilities for the use of foam gypsum in areas that are exposed to moisture, thereby expanding their application scope. Further research is recommended to optimize the concentrations of additives and to explore the long-term durability of these composites.

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