

ECOLOGICAL SAFETY AND ENERGY EFFICIENCY IN CONSTRUCTION: AN ANALYSIS BASED ON AERATED CONCRETE AND FOAM CONCRETE

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Abstract: This article presents an analysis of modern construction materials such as aerated concrete and foam concrete from the perspectives of ecological safety and energy efficiency. The purpose of the article is to examine the production processes, ecological impact, and contribution of these materials to energy savings in buildings. The key properties, thermal insulation indicators, and practical applications of aerated concrete and foam concrete in real projects are compared. The analysis reveals that aerated concrete and foam concrete are more ecologically safe and energy-efficient compared to traditional materials. In the future, it is necessary to develop innovative technologies and recycling opportunities to expand the use of these materials.

Keywords: Aerated concrete, foam concrete, ecological safety, energy efficiency, thermal insulation, sustainable construction, CO₂ emissions, energy consumption, recycling, construction materials

Introduction

The construction sector is one of the most significant and resource-intensive industries in the modern world. Due to global climate change, the depletion of natural resources, and the growing population, issues of sustainable development remain highly relevant. Within the framework of the United Nations Sustainable Development Goals (SDGs), particular attention is being paid to the ecological safety and energy efficiency of construction materials and technologies.

For instance, energy consumption and carbon dioxide (CO₂) emissions during construction processes constitute a significant portion of global greenhouse gas emissions. Therefore, the use of ecologically safe and energy-efficient materials is not only an economic but also a social and ecological necessity today. This article analyzes modern construction materials such as aerated concrete and foam concrete, exploring their production processes, ecological impact, and energy efficiency advantages.

Aerated Concrete and Foam Concrete: General Information and Production Process. Aerated concrete is a lightweight construction material made from primary raw materials such as cement, lime, gypsum, quartz sand, and gas-forming agents (typically aluminum powder). During the production process, aluminum powder reacts with water and lime to produce hydrogen gas, which creates small voids within the material. This results in aerated concrete being lightweight and exhibiting high thermal insulation properties. Foam concrete is another type of lightweight concrete, consisting of cement, sand, water, and chemical foaming agents. In its production, foam generated by a special foam generator is added to the

concrete mixture. This process reduces the material's density and enhances its thermal insulation properties. Unlike aerated concrete, foam concrete offers more flexible production methods and can be used in smaller-scale projects.

A common feature of both materials is their lightweight structure, which contributes to improved energy efficiency. However, aerated concrete hardens under high pressure and temperature in autoclaves, while foam concrete typically cures under natural conditions. These differences lead to variations in energy consumption and ecological impact during production.

Ecological Impact

Aerated concrete and foam concrete are produced from natural materials, indicating their relatively safe ecological profile. Aluminum powder is used as a chemical agent to generate gas, but it is applied in small quantities and does not leave harmful emissions in the final product. The energy consumption during production is moderate; however, in some factories, the use of recycled materials helps reduce carbon dioxide emissions. Aerated concrete does not emit harmful substances during use, as it is chemically stable. It is resistant to mold and decay, creating a healthy indoor environment. Its excellent thermal insulation properties contribute to energy savings and have a positive ecological impact. The use of autoclaves in aerated concrete production requires more energy. For example, producing one cubic meter of aerated concrete consumes approximately 200-250 kWh of energy. Additionally, the autoclave process increases CO₂ emissions, averaging 150-200 kg of CO₂ per ton of product. Foam concrete production, on the other hand, requires less energy (approximately 100-150 kWh per cubic meter), as it does not involve an autoclave process. CO₂ emissions are also relatively lower, at about 100-120 kg per ton. Aerated concrete production involves significant water usage, particularly for steam generation in the autoclave process. Foam concrete also requires water, though in smaller amounts. Nevertheless, the recyclability of both materials is a positive aspect. For instance, aerated concrete waste can be crushed and reused in new product production, while foam concrete can be partially recycled, though this process is more complex. The thermal insulation properties of aerated concrete and foam concrete depend on their density and structure. The following table compares their thermal conductivity coefficients (λ):

Material	Density (kg/m ³)	Thermal Conductivity (W/m·K)	R-Value (m ² ·K/W)
Aerated Concrete	400-600	0.09-0.12	2.5-3.0
Foam Concrete	300-500	0.08-0.10	2.8-3.2

When aerated concrete and foam concrete walls are 30 cm thick, their thermal insulation is 3-4 times higher than that of traditional brick walls. This reduces energy consumption for heating and cooling in buildings by 20-30%.

Aerated Concrete and Foam Concrete Projects The "Passivhaus" project in Germany demonstrates the energy efficiency of aerated concrete. This building, with aerated concrete walls, achieves heating with only 15 kWh of energy per square meter annually, representing a 90% saving compared to conventional buildings.

In Turkey, multi-story residential buildings using foam concrete have received LEED (Leadership in Energy and Environmental Design) certification. In this project, the lightweight nature of foam concrete reduced the foundation load, cutting construction costs by 15%. In recent years, autoclaves powered by solar energy are being tested to reduce energy consumption in aerated concrete production. For foam concrete, organic foaming agents are being developed, enhancing the material's ecological purity. Additionally, integration with smart building systems is expected to further improve the efficiency of these materials.

Conclusion

Aerated concrete and foam concrete play a significant role in ensuring ecological safety and energy efficiency in modern construction. While aerated concrete stands out for its high strength and standardized production process, foam concrete offers advantages through its flexibility and lower energy consumption. In the future, optimizing production processes, enhancing recycling opportunities, and introducing innovative technologies are essential to expand the use of these materials. This will enable the construction sector to make significant strides toward achieving sustainable development goals.

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