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Research on the Preparation Technology of Foam Concrete Wall Materials

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Abstract: *Research on the preparation technology of foamed concrete wall materials primarily focuses on enhancing thermal insulation performance, reducing density, improving mechanical properties, and increasing material durability. By employing foamed concrete construction techniques, the foam agent can be precisely blended with cement, water, and other constituents to produce a thermal insulation material exhibiting excellent heat and sound insulation properties, thereby achieving the objectives of energy conservation and emission reduction. This eco-friendly material demonstrates significant energy-saving benefits.*

Keywords: *Foamed Concrete; Foam; Energy Saving and Emission Reduction*

1. Introduction

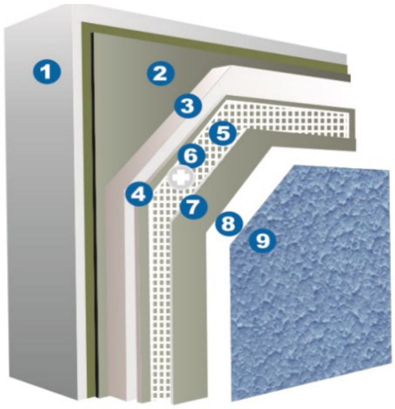

Figure 1: Section drawing of the concrete wall structure

Although the building materials industry has made great progress, its energy consumption is still above 30%, making their burden even heavier. In view of the problem of energy conservation and emission reduction, it must take measures, among which the most important thing is to increase investment, improve the technological innovation ability of small and medium-sized enterprises, so as to promote the construction industry to implement a sustainable development strategy, so as to meet the national saving and emission reduction standards. Therefore, it is needed to deeply explore and analyze the properties of building materials, as well as the advantages and disadvantages, in order to find a better solution [1].

With the rapid development of the global economy, environmental protection has become more and more concerned. The emergence of foamed concrete makes the concept of environmental protection can be realized, its advantages are obvious: its compact structure, heat preservation, sound insulation, fire resistance, pressure resistance, convenient installation, make it more and more favored by the public, and is widely used in a variety of construction projects[2].

The introduction of JGJ / T 341-2014 has not only greatly promoted the scientific and rationalization of the industry, but also greatly promoted the sustainability and reliability of the industry. The definition of foam concrete, terms, physical foam and chemical foam foaming method, the use of foam agent and foam agent, the determination of wet apparent density and dry apparent density are specified in detail in

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the regulations, which provides a technical basis for the preparation of foam concrete wall materials. Demand for foam concrete wall panels and roof panels is growing rapidly due to the government's active support for prefabricated construction. At present, many leading companies can produce qualified products according to the specifications of foamed concrete wall board, roof board, and some can even provide more cost-effective products. Section drawing of the concrete wall structure is shown in Figure 1.[3]

By using chemical foaming technology, it can add a right number of materials, such as stone powder, slag, sand and construction waste, which can not only reduce costs, but also improve the strength of the wall panels and prevent cracks. In addition, the wall panels produced by physical foaming technology can also meet the standard index, and this method is relatively simple, less equipment demand, easy to promote.

2. Foam concrete wall materials

China's foam concrete industry has witnessed steady growth in recent years, with an estimated total output of approximately 60 million cubic meters in 2020, surpassing that of other nations globally. The application of cast-in-situ foam concrete continues to outstrip the usage of conventional building materials, particularly in areas such as road construction, filling operations, integral wall and house pouring, and roof insulation layer enhancement. Advancements in technology have led to notable improvements in both the diversity and quality of foam concrete products, resulting in increasing market acceptance. Notably, cement-based foam insulation boards and foam concrete composite block products have garnered heightened attention and support from various regions.

With the promulgation and implementation of standards for foamed concrete wall panels and house panels, technological innovations in this field have unleashed significant potential, thereby enhancing its market popularity. Numerous innovative enterprises are now capable of producing high-quality siding and roof panels that adhere to these standards. Furthermore, the continual advancement of foam concrete block production technology has enabled leading enterprises to not only achieve high strength performance but also surpass traditional aerated concrete in meeting customer needs, thereby elevating product quality and cost-effectiveness.

In recent decades, international attention towards foam concrete has been on the rise, particularly in Northern Europe and Russia, where pioneering explorations were conducted in the early stages, consistently promoting the application of this building material. Following the end of World War II in the 1930s and 1950s, European countries actively pursued the substitution of foam materials with aluminum powder and aerated concrete, thereby stimulating research and manufacturing activities in the field of foam concrete. Many countries adopted advanced autoclaving technology, characterized by a high level of automation and excellent product quality. As early as the 1930s and 1940s, they commenced mass production of autoclaved blocks, roof panels, and wall panels. With the ongoing enhancement of building energy efficiency and environmental awareness, significant progress has been made in the research and application of foam concrete abroad, drawing increasing attention to its lightweight, porous, heat-insulating, and sound-insulating properties.

3. Characteristics of the foam concrete material

Foamed concrete is a composite material consisting of various components. The primary binding agent is cement, while additional ingredients include aggregates, admixtures, and water. These bubbles can be incorporated through either physical or chemical foaming methods.

3.1 Physical characteristics

The utilization of physical foaming technology enables the effective creation of additional pores by mechanically transforming the initial foam state into a structure with more voids. This technique can be applied to various materials, including cement, aggregates, admixtures, and water, through a specific process flow. On the other hand, chemical foaming technology effectively enhances the structure of foamed concrete. Its principle involves the chemical interaction between a foaming agent and the cement slurry, which induces foaming and results in the formation of more gaps and vacuoles.

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3.2 Stability of the foam

The performance of foam concrete is significantly influenced by the stability of the foam. To ensure the quality of foam agents, it is recommended to evaluate them according to industry standards. During the mixing process, the expansion ratio of the foam agent should be maintained between 15 and 30. The usage of foam products should be adjusted based on design requirements to meet industry standards. To achieve the desired fluidity and wet density, the mix proportion of foam concrete must be rigorously tested to determine the optimal amounts of cement, water, and admixtures, thereby ensuring the best construction results.

In the production of foam concrete, the following steps should be taken:

(1) Firstly, place fine aggregate, cement, fly ash, and various admixtures into the container. Then, add the appropriate amount of water as needed and mix thoroughly with various admixtures to ensure complete uniformity and prevent the appearance of powder.

(2) Combine the foam concrete slurry with the foam in the mixer and ensure sufficient agitation for 3 to 5 minutes to guarantee optimal construction results. After pouring and forming, proper curing is essential to ensure the material's performance.

(3) The amount of foaming agent has a significant impact on the performance of foam concrete. By carefully balancing the ratios of water-reducing agent and early-strength agent, the compressive strength, volumetric density, and pore structure of ultra-light autoclaved foam concrete can be significantly improved.

(4) The main performance indicators of foam concrete include the foaming agent's stability, compressive performance, water absorption capacity, thermal insulation, and energy-saving effects. The foam controls the concrete's density through the bubble rate generated in the cement slurry mixture, with foam bubbles defined as closed air voids resulting from the addition of the foam agent.

By adhering to these principles, foam concrete wall materials can achieve lightweight, high strength, excellent thermal and sound insulation performance, as well as outstanding environmental protection characteristics.

4. Technical difficulties of foam concrete partition wall

After a thorough assessment, it has been determined that there are several challenges associated with the construction of foam concrete partition walls on the construction site. Firstly, there is a lack of reference material to cater to local requirements. Secondly, as the technology is being introduced for the first time, providing technical training to construction workers is proving to be challenging. Furthermore, given that most projects are situated in areas with high seismic fortification intensity, the skill level of the construction workers may also be impacted. To comply with seismic fortification standards, the construction of the partition wall must address a significant challenge: it must establish effective connections with the main structure to fulfill its functional requirements, while avoiding the quality issues associated with traditional block systems. Additionally, the construction techniques for the wall and its secondary components also pose a considerable challenge.

4.1 Selection and Optimization of Foaming Agent

The choice of foaming agent exerts a profound influence on the performance of foamed concrete. Factors such as the quality, foaming multiple, and stability of the agent directly impact the volume density, compressive strength, and pore structure of the resultant foam concrete. Consequently, the identification and selection of an appropriate and efficient foaming agent constitute a pivotal aspect of technical research in this domain.

4.2 Precision in Mix Ratio Control

The mix ratio of foamed concrete is a critical determinant of its overall performance. Employing an orthogonal test design enables the optimization of water reducer and early strength agent quantities, thereby achieving optimal volume density and compressive strength. Precise control over the mix ratio is imperative to ensure that the foam concrete meets the requisite engineering specifications.

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4.3 Slurry Stability

During the preparation of foam concrete, ensuring slurry stability presents a significant technical challenge. The stability of the slurry directly correlates with the molding quality and physical properties of the final product. The incorporation of water reducing agents and early strength agents can enhance slurry stability, subsequently improving the performance of the foam concrete.

4.4 Pouring and Curing Techniques

The pouring and curing processes are pivotal to the ultimate performance of foam concrete. Proper pouring ensures uniform foam distribution, while curing conditions profoundly affect strength development and durability. Implementing meticulous pouring procedures and curing measures is essential to enhance the yield and quality consistency of foam concrete.

4.5 Mitigating Wall Cracking

Foam concrete walls may develop cracks due to temperature fluctuations, material shrinkage, and other factors. To mitigate this risk, optimizing the material ratio, refining construction techniques, and reinforcing maintenance practices are crucial. Foam concrete typically exhibits lower compressive strength compared to traditional concrete, necessitating technical interventions to improve this aspect. Adjusting the mix ratio, utilizing high-performance cement, and incorporating mineral admixtures are effective strategies for enhancing the compressive strength of foam concrete.

5. Expected social and economic benefits

5.1 Energy saving

The energy-saving foam concrete wall material represents a unique category of lightweight construction materials characterized by extensive sealed air pores. It primarily utilizes bulk solid waste such as coal gangue and fly ash as its main raw materials. Through the utilization of a foam machine, the foam agent is uniformly mixed and subsequently cast in-situ within buildings or molds. This material exhibits several outstanding properties, including self-sealing capabilities, ease of pouring, lightweight thermal insulation, resistance to fire and water, energy dissipation, shock absorption, cement savings, and cost-effectiveness. Consequently, the application of this energy-saving foam concrete as a wall material eliminates the need for additional external wall insulation. This not only significantly reduces costs but also maximizes fire safety by obviating the exterior wall insulation layer, thereby extending the lifespan of the building. Simultaneously, it can achieve the same sound insulation performance while reducing wall thickness. Moreover, in the absence of auxiliary structures such as structural columns and waist beams, the wall's load is substantially decreased, effectively enhancing the usable area of the building, further reducing costs, and facilitating maintenance while promoting energy conservation.

5.2 Environmental protection

By converting coal gangue, fly ash, and other mineral wastes into foam concrete blocks, significant energy savings can be achieved while greatly reducing environmental pollution and mitigating soil erosion, thereby effectively conserving land resources. Furthermore, the block's robust multi-porous structure enhances the building's insulation performance, notably improving indoor air quality and the overall indoor-outdoor environmental conditions. Additionally, it substantially reduces energy consumption for heating, consequently decreasing carbon dioxide emissions. It is evident that the development and application of foam concrete have delivered immense social and economic value, making it a preferred alternative to traditional solid clay bricks. In the coming years, it is anticipated that foam concrete will continue to serve as a vital basic material in the construction industry of our country.

5.3 Ecological balance

Foamed concrete has strong environmental friendliness, it will not cause any pollution to soil, water, air and other natural environment; Moreover, it can effectively reduce the environmental damage caused by high excavation, thus making an important contribution to the protection of natural ecological environment, has significant environmental advantages.

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6. Conclusion

Foamed concrete exhibits strong environmental friendliness, as it does not cause any pollution to the soil, water, air, or other natural environments. Furthermore, it effectively mitigates the environmental damage associated with extensive excavation, thereby making a significant contribution to the preservation of the natural ecological environment. In this regard, foamed concrete possesses notable environmental advantages.

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References

[1] Moussadik A , Fadili H E , Saadi M ,et al. Lightweight aerated concrete based on activated powders of coal gangue and fly ash[J].Construction and Building Materials, 2024, 417.DOI:10.1016/j. conbuildmat. 2024.135333.

[2] Chen L, Li P, Guo W, et al. Dynamic mechanical response, energy absorption capacity, and constitutive modeling of polypropylene fiber-reinforced foamed concrete under high temperature[J]. Journal of Materials Research and Technology, 2024, 30:807-822.DOI:10.1016/j.jmrt.2024.03.124.

[3] Wang X, Jin Y, Ma Q, et al. Performance and mechanism analysis of natural fiber-reinforced foamed concrete [J].Case Studies in Construction Materials[2024-11-13]. DOI: 10.1016/j. cscm. 2024. e03476.