Influence of Aluminum Powder Content on Expansion Rate of Foamed Concrete

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Abstract. Foamed concrete is a heat preservation and noise reduction material made of cement and aluminum powder as foaming agent. The experiment mainly studies the influence of different water-cement ratio, foaming agent dosage and cement dosage on the expansion rate of foamed concrete test block. The experimental results show that when the water-cement ratio increases from 0.4 to 0.6, the expansion rate decreases gradually. When the content of aluminum powder foaming agent increased from 0.05% to 0.40%, the expansion rate showed a trend of "increasing first and then decreasing". When other conditions are the same, the expansion rate of cement increases from 500kg/m³ to 800kg/m³, showing a trend of "decreasing first and then increasing".

1. Introduction

In recent years, due to the rapid development of economy and technology, the ensuing environmental pollution problems, noise pollution problems and building energy consumption problems need to be solved urgently [1]. In the face of these problems, my country has been implementing building energy conservation policies, developing green buildings, and recycling economy. Therefore, the development and application of energy-saving and thermal insulation building materials and sound-absorbing and noise-reducing materials have received more and more attention, which is the general trend [2, 3]. At present, the use of organic materials with better energy-saving effects, lower prices, and easy construction has the disadvantages of easy cracking, poor fire resistance, and short service life, which makes it enter a turning point, and its market share and usage have been significantly reduced. At the same time, inorganic materials have entered people's field of vision as ideal substitutes for organic materials and have been widely used [4, 5]. Foamed concrete is a kind of inorganic building materials. It is not only an efficient energy-saving insulation material [6], but also has the characteristics of light weight, low production cost, good molding and strong bearing capacity. Compared with traditional insulation materials, It also has better durability, sound absorption, safety, and has the advantages of quick construction and easy operation [7-9].

The chemical foaming of foamed concrete is to mix cement, foaming agent, and water together, add catalyst and stir together, and form uniform pores in the concrete through reaction. Among them, the most mature and widely used chemical blowing agent technology is aluminum powder. This article mainly conducts experiments using cement as raw material, aluminum powder as foaming agent, and caustic soda solution as catalyst to observe the effects of water-cement ratio, foaming agent content,
and cement on the volume and expansion rate of concrete at different times. The experiment and the production of foamed concrete provide a basic basis.

2. Experimental materials and methods

2.1. Experimental materials

The cementitious material of the experimental material is PO 42.5 ordinary Portland cement. The foaming agent is 45μm dried aluminum powder with 98% purity. The water for mixing is tap water heated to 40°C±5°C. The catalyst was NaOH solution with the concentration of 5%. The chemical composition of ordinary Portland cement is shown in Table 1.

| Name     | Ignition loss | SiO₂ | Al₂O₃ | Fe₂O₃ | CaO   | MgO | SO₃ |
|----------|---------------|------|-------|-------|-------|-----|-----|
| Cement   | 4.07          | 21.06| 6.1   | 3.08  | 57.98 | 2.74| 2.4 |

2.2. Experimental method

In this experiment, an electronic scale with the accuracy of 1/1000g was used to weigh the cement corresponding to 400kg/ m³, 500kg/ m³, 600kg/m³ and 800kg/ m³ respectively, and the water-cement ratio was 0.4, 0.5 and 0.6, respectively. The content of aluminum powder is 0.05%, 0.10%, 0.20% and 0.40%, respectively, compared with the cementitious material (cement). Then the trial fitting analysis was carried out. Detailed coordination is shown in Table 2.

| Cement ( kg/m³) | Water cement ratio | Aluminum content [Relative glue material content] (%) |
|-----------------|-------------------|---------------------------------------------------|
| 400, 500, 600, 800 | 0.4, 0.5, 0.6 | 0.05, 0.10, 0.20, 0.40 |

In this experiment, cement, water and NaOH corresponding to 0.8 times of aluminum powder were mixed and stirred 180 seconds. Add the aluminum powder foaming agent to the blender and stir it for 90 seconds. After mixing, the slurry is quickly poured into the measuring cylinder with a funnel, and the cylinder is kept at a temperature of 25°C. Constantly observe the volume change of concrete in the measuring cylinder and record it. The continuous observation time was 90 minutes.

2.3. Data processing

The expansion rate is the difference between the initial volume and the volume at the end of observation and the ratio of the initial volume, as shown in Formula 1:

\[ P = \frac{(V_1-V)}{V} \times 100\% \] (1)

In the formula: P: Expansion rate (%); V1: final surface volume of foamed concrete (cm³); V: Initial surface volume of concrete (cm³).

3. Experimental results and analysis

3.1. Relationship between expansion rate and time

This experiment mainly selects cement from 400kg/m³ to 800kg/m³, water cement ratio 0.4 to 0.6. The expansion rate with time was observed when the aluminum powder content increased from 0.05% to 0.40%. As shown in figure 1.
Figure 1. The relationship between expansion rate and time.

It can be seen from figure 1 that the expansion rate of concrete is increasing with time. When the aluminum powder content is 0.20%, the expansion rate is the largest, and when the aluminum powder content is 0.05%, the expansion rate is the smallest. When the aluminum powder content is 0.40%, the decrease compared to 0.20% is because as the aluminum powder content increases, the bubbles formed by the gas generation are easy to burst because they are not stable enough, and the foaming volume decreases and the expansion rate decrease.
3.2. The influence of water-cement ratio on the expansion rate of concrete
Under the condition of a foaming temperature of 25°C, this experiment mainly selects the cement content to increase from 400kg/m³ to 800kg/m³, and the relative content of aluminum powder from 0.05% to 0.40%. When the water-cement ratio is 0.4, 0.5, 0.6, the relationship between water-cement ratio and concrete expansion rate is shown in figure 2.

![Figure 2. Relationship between water-cement ratio and expansion rate.](image)

It can be seen from figure 2 that when the cement content is 400kg/m³, the expansion rate gradually decreases with the increase of the water-cement ratio. When the cement content is 500kg/m³ and 600kg/m³, the expansion rate decreases first and then increases with the increase of water-cement ratio, but the expansion rate is smaller when the water-cement ratio is 0.6 than that when the cement content is 0.4. When the cement content is 800kg/m³, the expansion rate first increases and then decreases with the increase of the water-cement ratio, but the expansion rate when the water-cement ratio is 0.6 is smaller than that when the water-cement ratio is 0.4. Therefore, the overall expansion rate decreases as the water-cement ratio increases. This is because the cement content is relatively reduced, the amount of reaction with aluminum powder decreases, the gas generation decreases, and the bubbles decrease, so the expansion rate decreases.

3.3. The influence of cement dosage on concrete expansion rate
This experiment mainly selects the relationship between cement content and expansion rate when the water-cement ratio is 0.4 to 0.6, the aluminum powder content is 0.05% to 0.40%, and the cement content is from 400kg/m³ to 800kg/m³, as shown in figure 3.
Figure 3. The relationship between cement content and water-cement ratio.

According to Figure 3, under normal circumstances, the expansion rate of concrete decreases first and then increases with the increase of cement content, and the expansion rate increases fastest when the cement content is from 500kg/m³ to 600kg/m³. This is because when the cement content increases, the reaction with aluminum powder is more complete, the bubbles generated increase, the volume increases, and the expansion rate increases.

3.4. The influence of the relative content of aluminum powder on the expansion rate of concrete

This time, choose the water-cement ratio from 0.4 to 0.6 and the cement content from 400kg/m³ to 800kg/m³ to observe the relationship between the concrete expansion rate and the aluminum powder content, as shown in Figure 2 and Figure 3. It can be seen from Figure 2 and Figure 3 that when the cement content and water-cement ratio content remain unchanged, the expansion rate of foamed concrete shows a trend of first increasing and then decreasing with the increase of the aluminum powder content. And when the aluminum powder content increases, the expansion rate reaches the maximum when the content is 0.20%, and the minimum expansion rate is when the aluminum powder content is 0.05%. This is because when the aluminum powder content is 0.40%, the content of aluminum powder is too much, the gas generated by the reaction increases. And when the bubbles are large to a certain extent, they are unstable and burst, and the result is caused by the corresponding decrease in volume.

4. Conclusion

This study is to investigate the aluminum powder content, water-cement ratio, and the expansion rate of cement to foamed concrete. The results of the study are as follows.

(1) The experimental data of this group shows that the water-cement ratio increases and the expansion rate gradually decreases; as the content of aluminum powder increases, the expansion rate "increases first and then decreases"; as the cement increases, the expansion rate tends to "decrease first and then increase" in most cases.

(2) When the water-cement ratio is 0.4, the cement content is 600kg/m³, and the aluminum powder content is 0.20%, it is more suitable for foaming and the expansion rate is the most ideal.

(3) This experiment aims to provide basic data for the production and development of foamed concrete, so that the application of foamed concrete will be more extensive.

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