Influence of Fiber on Properties of Graphite Tailings Foam Concrete

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Abstract. The project used graphite tailings as a filler to prepare graphite tailings foamed concrete. Mainly studied the physical properties, mechanical properties and thermal properties of the foam concrete by graphite tailings, also studied the combination of polypropylene fiber and glass fiber influence of foam concrete compressive strength and cracking strength. The experimental results show that in the case of the same dry density grade, adding 20% graphite tailings can make the foam concrete strength reach its peak. When the water-binder ratio is 0.65 and the self-made chemical foaming agent content is 7%, the optimal total fiber volume blending rate is 0.18%, and the blending ratio of polypropylene fiber and glass fiber is 2:1. The compounding of polypropylene fiber and glass fiber can improve the flexural performance of foam concrete, which is not conducive to the thermal insulation performance of foam concrete, but the test results are still better than industry standards.

Keywords: Graphite tailings · Foam concrete · Strength · Polypropylene fiber · Glass fiber

1 Introduction

Foam concrete is a lightweight, thermal insulation, fire resistant, sound insulation and anti freezing concrete material. In recent years, many people have done a lot of research work in the field of foam concrete from different angles [1–8]. However, there are few reports on the preparation of foam concrete with graphite tailings as filler. Graphite tailings, as industrial wastes discharged from mines after beneficiation, have a very negative impact on the ecological environment. In addition to effective cover and reclamation, it is more important to find ways to turn graphite mine tailings into treasure and reuse them. Using graphite tailings to replace part of the cementitious materials to prepare foamed concrete is another new way to turn graphite tailings into treasure. Therefore, the research on graphite tailings modified foamed concrete can not only improve its crack resistance and thermal insulation performance, but also solve the problem of industrial waste pollution. On the one hand, it solves the problems of storage and land occupation of graphite tailings in graphite production sites; on the other hand, it can open up a

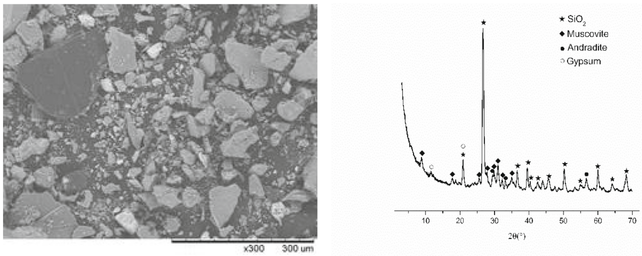
G. Feng (Ed.): ICCE 2021, LNCE 213, pp. 508–515, 2022.
https://doi.org/10.1007/978-981-19-1260-3_46

way for mines to turn waste into treasure. It has extremely important economic and social significance for the rational use of energy and the improvement of the ecological environment. Graphite tailings are used as filler to prepare foamed concrete and the effect of fiber on properties of foam concrete are studied in this paper.

2 Text

2.1 Raw Materials

The graphite tailings produced in Heilongjiang Province are selected for this experiment, with a particle size range of 0–0.4 mm and an apparent density of 2.85 g/cm^3. The particle morphology and the mineral composition of graphite tailings are analyzed by X-ray diffraction, and the diffraction pattern is shown in Fig. 1.



(a) Particle morphology of graphite tailings (b) XRD pattern of graphite tailings

Fig. 1. Microscopic morphology of graphite tailings

The chemical composition of graphite tailings is analyzed in Table 1.

Table 1. Chemical composition of graphite tailings (%)

SiO_2	Al_2O_3	CaO	Fe_2O_3	SO_3	K_2O	MgO
51.56	14.55	10.03	7.64	6.47	3.77	3.60

The cement is P·O 42.5 grade cement produced by Liaoning Jidong Cement Co., Ltd. The foaming agent used in this experiment is a self-made chemical foaming agent with a foaming multiple of 25 times, a settlement distance of less than 5 mm in 1 h, and a bleeding volume in 1 h of less than 18 ml. The quality of polycarboxylate superplasticizer provided by Jiangsu Subote New Material Co., Ltd. accounts for 0.1% of the total quality of cement. Technical indicators of glass fiber and polypropylene fiber are shown in Table 2.

Table 2. Technical indicators of glass fiber and polypropylene fiber

Fiber	Length specification (mm)	Tensile strength (MPa)	Elastic modulus (GPa)	Equivalent diameter (μm)	Density (g/m^3)
Glass fiber	24	2800	86	13	2.63
Polypropylene fibers	20	420	3.58	34	0.91

2.2 Influence of Graphite Tailings Fineness on the Strength of Foam Concrete.

Aiming at the graphite tailings foamed concrete with a dry density of 900 kg/m^3, under the condition that the mixing ratio of graphite tailings is unchanged at 20%, graphite tailings of different particle sizes are screened to study the effect of fineness on the strength of foam concrete and the line chart is drawn as shown in Fig. 2.

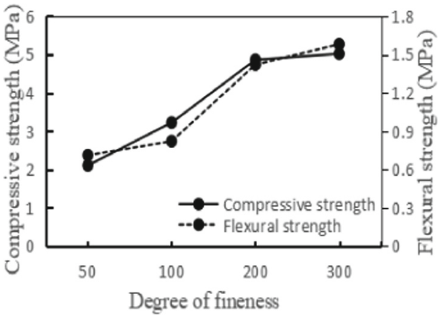
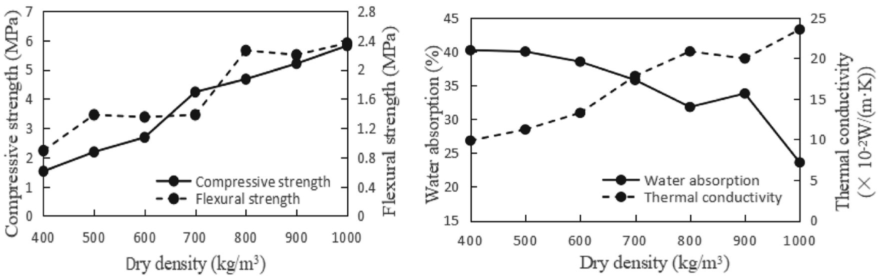


Fig. 2. The influence of graphite tailings fineness on the strength of foam concrete

It can be seen from Fig. 2 that the mechanical properties of foamed concrete have a great relationship with the fineness of graphite tailings. Both the flexural and compressive strengths gradually increase with the increase in fineness. When the fineness of graphite tailings is 50 mesh (0.325 mm), the flexural strength of the foamed concrete is 0.71 MPa and the compressive strength is 2.10 MPa. When the fineness of graphite tailings reached 300 mesh (0.045 mm), flexural strength and compressive strength reaches 1.6 MPa and 5.0 MPa respectively.

2.3 The Influence of Dry Density on the Performance of Graphite Tailings Foamed Concrete

As the dry density of foam concrete changes, its strength, water absorption and thermal conductivity have been greatly affected. Under the condition that the water-to-material ratio was 0.50 and the mixing ratio of graphite tailings is 20% unchanged, by adjusting the foam content, 7 kinds of foam concrete with different dry density grades are prepared. The corresponding line graphs is Fig. 3 respectively.



(a) (b)

Fig. 3. The effect of dry density on the performance of foam concrete

It can be clearly observed from Fig. 3 (a) that the strength and dry density of foam concrete change almost linearly. The greater the dry density, the higher the flexural and compressive strength of foam concrete. When the dry density was 400 kg/m^3, the flexural and compressive strengths are only 0.9 MPa and 1.5 MPa. When the dry density increases to 1000 kg/m^3, the flexural and compressive strengths increas by 1.5 MPa and 4.3 MPa respectively.

It can be seen from Fig. 3 (b) that there are two opposite trends in the effect of dry density of foam concrete on water absorption and thermal conductivity. The water absorption of foam concrete decrease with the increase of dry density, the thermal conductivity increases with the increase of dry density. To express the pore structure of graphite tailings foam concrete more intuitively, this project uses the image processing and analysis system of ImageJ software to select three groups of tests of 700 kg/m^3,800 ^{kg}/m^3,900 ^{kg}/m^3 dry density to measure the pore structure characteristics of foam concrete. Analyzed and researched factors such as porosity, pore size and roundness.

It can be seen from Fig. 4 that the dry density is related to the slurry content per unit volume. The larger the dry density, the more the corresponding slurry quantity, the stronger the cementing ability in the hardened foam concrete, the thicker the hole wall on the foam wall, and the stronger the ability to resist external forces. Generally speaking, the smaller the pore size will improve the mechanical properties of the foam concrete. The porosity decreased with the increase of the dry density. It can also be seen that the strength of the foam concrete increased with the increase of the dry density. Foam concrete belongs to porous material. When the dry density is large, the porosity is relatively small, and the number of connected pores decrease, which eventually leads to foam concrete water absorption decrease. While the dry density increases and the porosity decrease, the content of solid matter in unit volume increases. According to theoretical knowledge, the thermal conductivity of gas is only about one-tenth of that of ordinary solid materials, so in this process, the thermal conductivity of foamed concrete is also increasing.

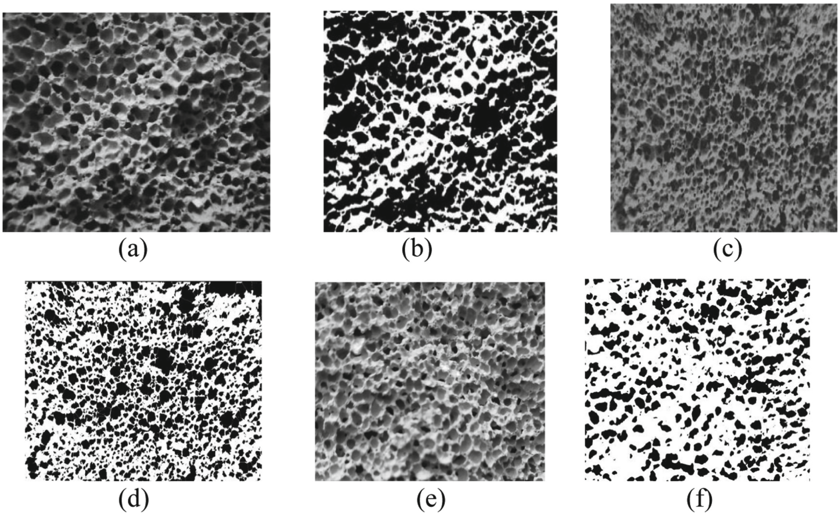


Fig. 4. (a) (c) (e) the gray level processing image of the original image of the hole structure under three dry densities. (b) (d) (f) Binary processed image of the original pore structure at three dry densities

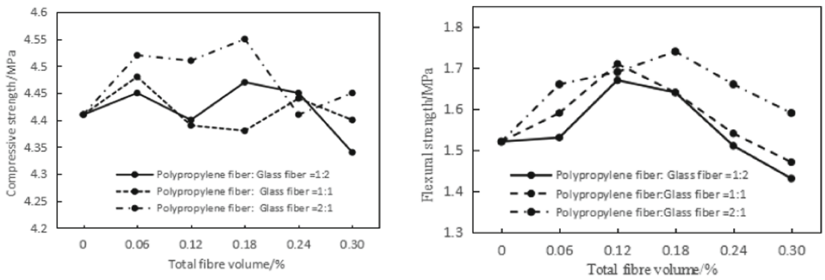
2.4 Effect of Glass Fiber and Polypropylene Fiber on Properties of Foam Concrete

The glass fiber and polypropylene fiber are mixed into the reference foam concrete to test the flexural strength, compressive strength, water absorption and thermal conductivity of the foam concrete. Among them, the total volume doping ratio of the two fibers is 0%, 0.06%, 0.12%, 0.18%, 0.24%, 0.30%, and the volume doping ratio is 1:2, 1:1 and 2:1 respectively.

2.4.1 Effect of Glass Fiber and Polypropylene Fiber on Mechanical Properties of Foam Concrete

Figure 5 shows the effect of fiber blending on the compressive strength of foam concrete. When the total fiber content is 0.18%, the ratio of polypropylene fiber to glass fiber is 1:2, compressive strength of foam concrete up to 4.47 MPa. When the ratio of polypropylene fiber to glass fiber is 1:1, the fiber content is 0.06%, Maximum compressive strength is 4.48 MPa. When the ratio is 2:1, the total doping rate is 0.18%, compressive strength up to 4.55 MPa maximum. Thus it can be seen that fiber blending has little effect on the compressive strength of foam concrete, and the fiber mainly plays the role of toughening, crack resistance and folding resistance in foam concrete.

The composite fiber have obvious influence on the flexural strength of foam concrete. When the total fiber volume ratio increases, the flexural strength of the foam concrete mixed with three proportions of fibers all show a trend of first increasing and then decreasing. The flexural strength of foam concrete can be improved by fiber blending. When the ratio of polypropylene fiber to glass fiber is 2:1 and the total volume ratio is 0.18%, the synergy of the two reaches the maximum, and the increase rate of foam



(a) (b)

Fig. 5. Effect of fiber remixing on the compressive strength and bending strength of foam concrete

concrete flexural strength was the highest. The results showed that the glass fiber ratio can strengthen the strength of foam concrete at 0.06%, while the polypropylene fiber ratio can play a better role in toughening and cracking resistance under 0.12% condition. When the two cooperate, polypropylene fiber forms a dense network structure in foam concrete, in which glass fiber acts as a skeleton to resist the deformation of foam concrete under the action of external force. The two cooperate to play a good anti-folding and toughening effect. When the ratio of polypropylene fiber to glass fiber was 1:2 or 1:1, the glass fiber occupied a large proportion. The excessive glass fiber content made the crack and sudden stress change easily in the foam concrete. The corresponding decreased in the fiber content reduced the crack resistance and toughness of the foam concrete, which ultimately led to a decrease in the flexural strength of the foam concrete.

2.4.2 Effect of Fiber Blending on Water Absorption and Thermal Conductivity of Foam Concrete

Figure 6 (a) reveals the influence of fiber blending on the water absorption of foam concrete. It can be seen that the water absorption of foam concrete increases gradually with the increase of total fiber volume. When the fiber content is 0.30% and the fiber content ratio is 1:2, the mass water absorption of foam concrete reached the maximum value, which was 43.3% and 42.6% respectively. When the fiber content ratio is 2:1, the water absorption of foam concrete reached the maximum value of 45.4% when the volume content is 0.24%, respectively. Increasing the total fiber content can destroy the pore structure of concrete to a certain extent, resulting in the increase of porosity, and then increase the mass water absorption of foam concrete.

As shown in Fig. 6(b), fiber blending can enhance the thermal conductivity of foam concrete and reduce its thermal insulation performance. The ratio of the three fibers to the thermal conductivity of foam concrete was different. When the ratio of polypropylene fiber to glass fiber is 1:2,1:1 and 2:1, the maximum growth rate of thermal conductivity is 2.6%, 6.4% and 7.8%, respectively. With the increase of glass fiber content, the change rate of thermal conductivity decreased. It can be seen from the Fig. 6 that the ratio of mixing rate was 1:2, the thermal conductivity of foam concrete increases slightly and tends to be stable. The phenomenon is mainly due to the fact that glass fiber had less influence on the thermal conductivity of foam concrete than polypropylene fiber.

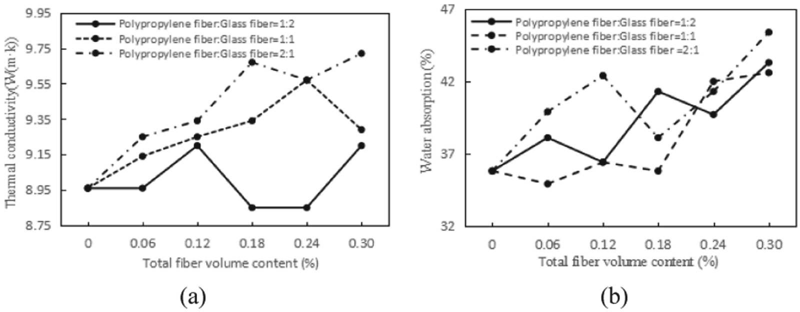


Fig. 6. Effect of fiber remixing on the water absorption rate and thermal conductivity of foam concrete

3 Conclusion

It is concluded that the optimal amount of graphite tailings is 20%. The pore structure distribution of foam concrete under different dry densities is analyzed by using the roundness. Fiber compounding has a significant effect on increasing the flexural strength of foam concrete. The optimal total fiber volume blending rate is 0.18%, and the blending ratio of polypropylene fiber and glass fiber is 2:1; the two fibers have achieved complementary advantages and significant improve the flexural performance of foam concrete. Fiber blending can improve the water absorption and thermal conductivity of foam concrete, thus reducing the insulation performance of foam concrete, but the test results are still better than the industry standard.

Acknowledgments. This research was funded by the Basic research project of Liaoning Provincial Department of Education, grant number lnjc201916.

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