



# Research on Carbon Fiber Polymer Ultrafine Cement Grouting Material

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DOI: 10.32629/aes.v3i2.896

**Abstract:** With the gradual development of deep coal mining, the demand for roadway support strength is also increasing. For ordinary grouting materials, it cannot be injected into ultra-fine pores, and the tensile strength of its consolidated body is not high. Therefore, in this paper, ultra-fine cement and carbon fiber are used as the raw materials of the grouting fluid to increase the injectability of its fine pores and the tensile strength of the consolidated body. By designing experiments with different carbon fiber content, the grouting material with the best mix ratio was formulated. The test results show that: after the grouting material is mixed with graded sand to prepare a test block, the mechanical properties of the grouting material are optimal when the carbon fiber content is 1%, and the compressive strength is 17MPa and the tensile strength is 1.34MPa.

**Keywords:** underground engineering, grouting material, carbon fiber, superfine cement

## 1. Introduction

With the gradual exhaustion of shallow resources, coal mining gradually advances to the deep [1]. Faced with the challenge of roadway support in this process, grouting reinforcement is widely used due to its advantages of simple construction and economical efficiency. However, ordinary grouting materials cannot meet the grouting task of small pores or cracks [2]. Akhtar T et al. [3] studied the effect of recycled tire steel fiber and low-calcium fly ash on the properties of concrete under different mix ratios, and the results showed that adding 10-15% low-calcium fly ash and 0.25%-0.5% recycled tire Steel fibers can improve the ductility and impermeability of concrete. Gan Z et al. [4] studied the effect of PVA fiber and NS on the shear properties of geopolymer mortar and concrete base. The test showed that when the geopolymer mortar was mixed with 0.8% PVA fiber and 2.0% NS, its bond strength was improved. achieve the best. Khan M et al[5] studied the mechanical properties of CW basalt hybrid fiber reinforced mortar with different fiber contents and lengths. The results showed that the fiber addition at different contents and lengths improved the mechanical properties of basalt fiber reinforced cement mortar; Akca K R et al. [6] studied the effects of fiber content, curing method, compaction method, etc. on the mechanical properties of UHPC, and proved that the addition of hybrid fibers (compared with the use of single fibers) increased the compressive strength by 16.7%, and the bending resistance Tensile strength increased by 48%. Murad Y et al. [7] studied the shear properties of reinforced concrete beams made of basalt and polypropylene fibers with different fiber contents. The results showed that the optimal proportions of basalt and polypropylene fibers were 2.5% and 0.6% of the total weight of cement respectively. Avci E et al. [8] studied the grouting effect of ultra-fine cement suspension mixed with fine fly ash on sand with different grades. The strength of grouting specimens increased. Zhang D et al. [9] studied the effect of different superfine cement content on the strength properties and microscopic properties of grouting specimens. The study showed that increasing the superfine cement content can improve the compressive strength and tensile strength of grouting specimens, and reduce debris. The fractal dimension and porosity of grouted specimens. Hao M et al. [10] analyzed the variation law of polymer slurry viscosity, and studied the rheological properties of the slurry to provide reference for actual construction. Mohammed A et al. [11] used XDR and other methods to conclude that the polymer content has different effects on the viscosity and shear stress of cement-based grouting materials.

In this paper, by consulting a large number of latest research results on grouting materials, cement-based materials, etc., the types and basic properties of fiber reinforced polymer grouting materials are determined, and the basic mix ratio of fiber reinforced polymer grouting materials is determined. The injectability test proves the injectability of the grouting material. The effect of carbon fiber content on the properties of grouting materials was tested through the mix ratio test, and the grouting materials were tested and the mechanical properties of the grouting materials were tested to determine the optimal mix ratio of the grouting materials.

## 2. Experimental program

### 2.1 Raw materials

The raw materials in this paper are Portland ultrafine cement, 300 mesh carbon fiber, methyl cellulose, vinyl acetate-ethylene copolymer emulsion (VAE emulsion), and defoamer. The role of Portland ultrafine cement is to increase the injectability of fine pores of the grouting material; the role of carbon fiber is to increase the tensile strength of the consolidated body of the grouting material; the VAE emulsion is used as a polymer to increase the cohesion between different molecules; Methyl cellulose is used as a dispersant to eliminate the flocculation effect of carbon fibers; defoamer is to eliminate the bubbles generated during the stirring process of the slurry to increase the density of the slurry during coagulation.

### 2.2 Preparation

In this paper, the optimal mix ratio of carbon fiber polymer ultrafine cement grouting material is developed by designing different mix ratios. It is designed to observe the mechanical properties of the slurry consolidated body under the condition of different carbon fiber content and water-cement ratio, and obtain a group with the strongest compressive strength and tensile strength of the consolidated body. In this experiment, the carbon fiber content was designed to be 0.0%, 0.5%, 1.0%, and 1.5%, respectively. The water-cement ratio (W/C) is 0.8; the poly-ash ratio (P/C) is 5.0%; the defoaming agent is 0.5% of the cement content; the dispersant solution is prepared with a concentration of 0.4g/L. The compressive strength and tensile strength were tested by casting test blocks of the above 4 groups of slurries with different carbon fiber contents, demoulding after 24 hours, and curing at constant temperature and humidity for 7 days.

## 3. Test methods

### 3.1 Compressive strength test

The axial compressive strength test uses a cylindrical standard specimen with a height of  $h=100\text{mm}$  and a diameter of  $\phi=50\text{mm}$ . There are 3 test blocks in each group. In this test, the specimens are demolded after standard curing for 24 days. After demolding, they are cured in water at room temperature of  $20^\circ\text{C}$  for 7d, and then the test is carried out. In the test, the uniaxial compressive strength test was carried out according to the "Code for Testing the Mechanical Properties of Ordinary Concrete".

### 3.2 Tensile strength test

The tensile strength of fiber-reinforced polymer cement mortars was determined using the Brazilian splitting test. The tensile strength test uses a cylindrical specimen with a height of  $h=25\text{mm}$  and a diameter of  $\phi=50\text{mm}$ . There are 3 test blocks in each group. In this test, the test pieces are demolded after standard curing for 24 days. After demolding, they are cured in water at room temperature of  $20^\circ\text{C}$  for 7d, and after cutting and grinding, they are made into standard cylindrical test blocks with a height of  $h=25\text{mm}$ . carry out testing. In the test, the Brazilian splitting test was carried out according to the "Code for Testing the Mechanical Properties of Ordinary Concrete".

## 4. Results and discussion

Uniaxial compressive strength results of fiber-reinforced polymer cement mortar test blocks with different carbon fiber content at 7d: when the carbon fiber content is 0.0%, 0.5%, 1.0%, and 1.5%, respectively, the fiber-reinforced polymer cement mortar test block resists. The compressive strengths were 15.2MPa, 13.7MPa, 17.0MPa, and 14.2MPa, respectively.

Tensile strength results of fiber-reinforced polymer cement mortar test blocks under different carbon fiber content for 7 days: when the carbon fiber content is 0.0%, 0.5%, 1.0%, and 1.5%, respectively, the tensile strength of fiber-reinforced polymer cement mortar test blocks is 1.06 MPa, 1.10 MPa, 1.35 MPa, 1.14 MPa.

## 5. Conclusions

With the increase of carbon fiber content, the compressive strength of fiber-reinforced polymer cement mortar first decreased, then increased and then decreased. When the carbon fiber content is 1.0%, the compressive strength of the carbon fiber reinforced polymer cement mortar test block is the highest. With the increase of carbon fiber content, the tensile strength of the fiber-reinforced polymer cement mortar test block first increased and then decreased. When the carbon fiber content is 1.0%, the tensile strength of the test block is the largest. This paper concludes that the mechanical properties of cement mortar are optimal when the carbon fiber content is 1%.

## References

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- [1] Ming Rui Du, Hong Wen Jing, Wen Hui Duan, Guan Sheng Han, Shu Jian Chen. Methylcellulose stabilized multi-walled carbon nanotubes dispersion for sustainable cement composites *Construction and Building Materials*, 2017, 146.
- [2] Shan PF, Lai XP. Influence of CT scanning parameters on rock and soil images. *Journal of Visual Communication and Image Representation*, 2019, 58: 642-650.
- [3] Akhtar T, Ali B, Ben Kahla N, et al. Experimental investigation of eco-friendly high strength fiber-reinforced concrete developed with combined incorporation of tyre-steel fiber and fly ash. *Construction and Building Materials*, 2022, 314.
- [4] Gao Z, Zhang P, Wang J, et al. Interfacial properties of geopolymer mortar and concrete substrate: Effect of polyvinyl alcohol fiber and nano-SiO<sub>2</sub> contents. *Construction and Building Materials*, 2022, 315.
- [5] Khan M, Cao M, Ai H, et al. Basalt Fibers in Modified Whisker Reinforced Cementitious Composites. *Periodica Polytechnica-Civil Engineering*, 2022.
- [6] Akca K R, Ipek M. Effect of different fiber combinations and optimisation of an ultra-high performance concrete (UHPC) mix applicable in structural elements. *Construction and Building Materials*, 2022, 315.
- [7] Murad Y, Abdel-Jabbar H. Shear behavior of RC beams prepared with basalt and polypropylene fibers. *Case Studies in Construction Materials*, 2022, 16.
- [8] Avci E, Mollamahmutoglu M. Strength and Permeability Characteristics of Superfine Cement and Fine Fly Ash Mixture Grouted Sand. *Aci Materials Journal*, 2020, 117(6): 293-304.
- [9] Zhang D, Ma Z, Zou Y, et al. Study on the Strength and Micro Characteristics of Grouted Specimens with Different Superfine Cement Contents. *Materials*, 2021, 14(21).
- [10] Hao M, Li X, Wang X, et al. Experimental Study on Viscosity Characteristics of Expanding Polymer Grout. *Journal of Wuhan University of Technology-Materials Science Edition*, 2021, 36(2): 297-302.
- [11] Mohammed A, Mahmood W, Ghafor K. TGA, rheological properties with maximum shear stress and compressive strength of cement-based grout modified with polycarboxylate polymers. *Construction and Building Materials*, 2020, 235.