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Analysis of Mechanical Properties of Carbon Fiber Reinforced Concrete based on Ansys Composite Model

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Abstract**—** In order to study different carbon fiber contents and it's influences on mechanical properties of concrete, ANSYS materials composites were synthesized to carry out numerical simulation. Here are the results of numerical analysis: The addition of carbon fiber composite can greatly improve the compressive strength of concrete. Among them, the mechanical properties of concrete with 1% carbon fiber content and 2% carbon fiber content are basically the same, but there is no clear improvement in flexural performance. Therefore, the enhancement of mechanical properties of concrete by fiber is closely related to its content. The study of the change between them can effectively reduce the loss of fiber, but also conducive to the promotion of fiber reinforced concrete.

Keywords— Composite Material Model, Fiber Content, Concrete, Compressive and Flexural.

I. Introduction

In recent years, with the rapid development of civil engineering, the social demand for materials is increasing, especially in light weight and high strength, so many carbon fiber composites have been developed and applied in life. the basalt fiber performs better than polypropylene fiber in terms of flexural strength[1-3] ; while carbon fiber performs best, researchers has found that in terms of bending performance, polyvinyl alcohol fiber Better than polypropylene fiber [4-8]. Fiber content has an iMPact on the mechanical properties of concrete; Cai Na's research shows that when the content of polypropylene fiber is in the range of 1.2% to 1.6%, the compressive strength decreases [9-13]; Fang Shengen's research shows that when the content of glass fiber is 0~ When the content is between 20%, the compressive strength of concrete increases with the increase of the content, and the strength decreases when the content exceeds 20%. Research by Li Kun et al. has shown that the compressive and flexural strength of concrete increases with the increase of the content of basalt fiber [14-16]. Fiber type, content and dispersion will affect the mechanical properties of foam concrete. In order to further analyze the mechanical properties of fiber concrete, this paper analyzes the compressive and flexural properties of concrete with different carbon fiber content through Ansys software based on previous research. the study.

II. Subjects

Through the material design function of material in the ansys software, analyze and design non-doped concrete, composite concrete with 1% carbon fiber content, and composite concrete with 2% carbon fiber content. The basic physical properties are determined as follows through the performance analysis function in materials：

TABLE I. BASIC PHYSICAL PROPERTIES OF THE TEST MATERIALS

Materials	Elastic Modulus MPa	Poisson's Ratio	Shear Modulus MPa	Density kg/m^2
Carbon Fiber	2.3e5	0.2	9000	1800
Concrete	3e4	0.18	1.27e4	2300
Carbon fiber concrete （1%）	33979	0.18	12627	2290
Carbon fiber concrete （2%）	35956	0.181	12536	2285

By synthesizing different amounts of concrete, it can be found that the elastic modulus changes greatly with the increase of the carbon fiber content, and the density shows a downward trend due to the lower carbon fiber density, Poisson's ratio and shear modulus The change is minor.

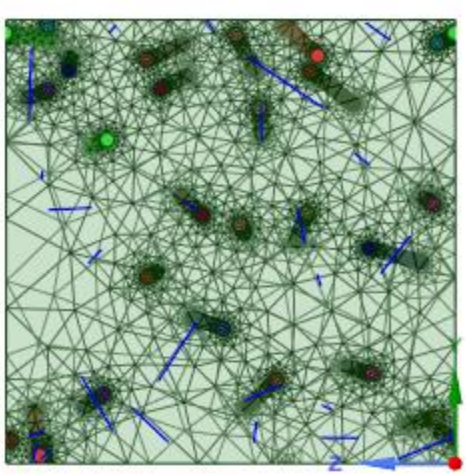

Figure 1. 1% carbon fiber composite concrete

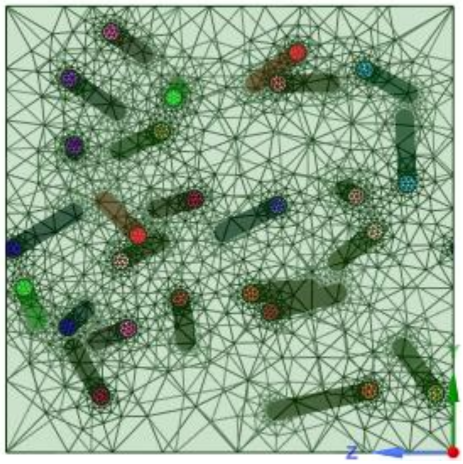

Figure 2. 2% carbon fiber composite concrete

III. ANSYS ANALYSIS

Computer simulation technology is increasingly used in the field of material design. When the experiment is relatively troublesome and the cost of the experiment is high, the use of numerical analysis for pre-analysis can improve the success rate of the experiment. Numerical simulation mainly uses a set of control equations (algebra or Differential equations) to describe the change relationship of the basic parameters of a process, and use numerical calculation methods to solve in order to obtain a quantitative understanding of the process (or a certain aspect of a process), and perform dynamic simulation analysis on the process, and judge on this basis The pros and cons of the process or plan, predict defects, optimize the process, etc. The basic feature of the numerical simulation method is to discretize the solution domain of the boundary value problem of differential equations, and reduce the original requirement to satisfy the field equation everywhere in the solution domain and the analytical solution that satisfies the boundary conditions everywhere on the boundary. The numerical solution of a set of algebraic equations derived from the field equations and boundary conditions at a given discrete point (node).

A. Numerical analysis of compressive strength based on ANSYS

Analyze the compressive strength of the 150mm*150mm*150mm standard test piece of composite concrete design synthesized by ansys materials, fix the bottom surface of the test piece, and monitor the points in the test piece, as shown in the figure below：

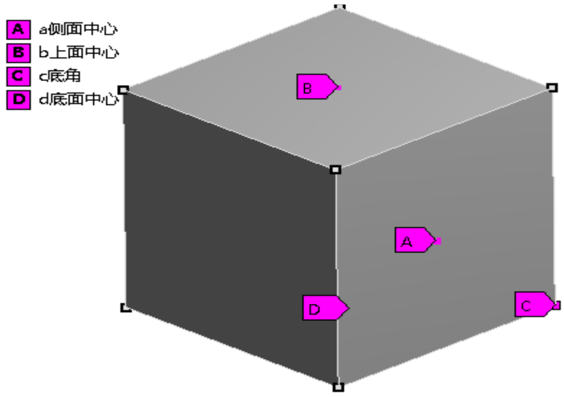

Figure 2. Monitoring point of the test piece

This test adopts transient dynamics design to facilitate the observation of the strain changes of each monitoring point during the force process.

Experimental design: Apply 0.2MPa pressure to the top surface for 100s. And ensure that the grid meets the grid independence.

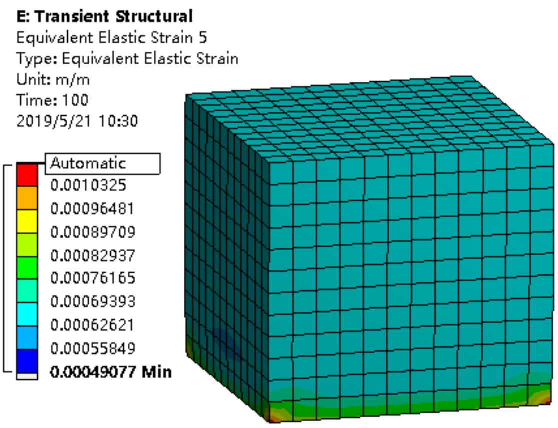

Figure 3. The compressive strain cloud diagram of the specimen

Figure 3 shows the strain of the specimen during the compression test: it can be found that the specimen has the largest strain at the four vertices of the fixed surface. In order to study the influence of different fiber content on the stress-strain curve of concrete, by analyzing the carbon fiber concrete specimens with 1% fiber content and 2% fiber content when no fiber is added, the stress-strain curve of the monitoring points is observed as shown in Figure 4 Shown：

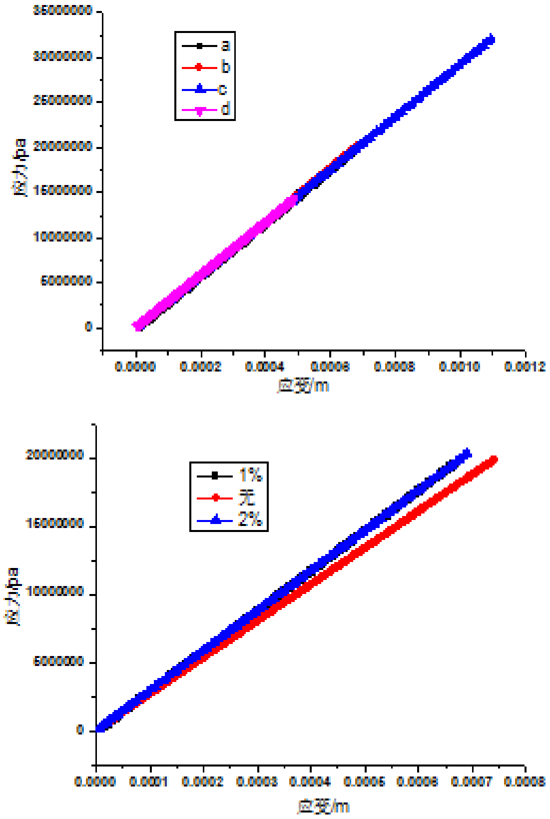

Figure 4. The stress-strain curve of the monitoring point under the 1% content of the compression test and the stress-strain curve of the same monitoring point with different content.

Through the stress-strain curves of different monitoring points of the same test piece and the same monitoring point of different materials, it can be found that the stress-strain curves of each monitoring point of the same material are basically the same, although the stress conditions are different. CoMPared with the addition of fibers, the compressive strength of the case without fiber is significantly increased, but there is no obvious change under the fiber content of 1% and 2%. Therefore, when making fiber concrete, special attention should be paid to the fiber content to prevent Under the condition of meeting the compressive strength, unnecessary material waste is caused.

B. Analysis of flexural strength test based on ANSYS

During the transient dynamics test, a 150mm*150mm*550mm specimen is used, one end is fixed and restrained, and the other end is applied with 0.2MPa pressure for 100s. The test meets the requirement of grid independence, and two monitoring points are selected as shown in the figure below:

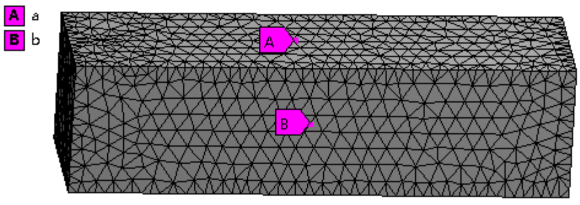

Figure 5. The flexural test grid and monitoring points

Obtain the following flexural strain cloud diagram：

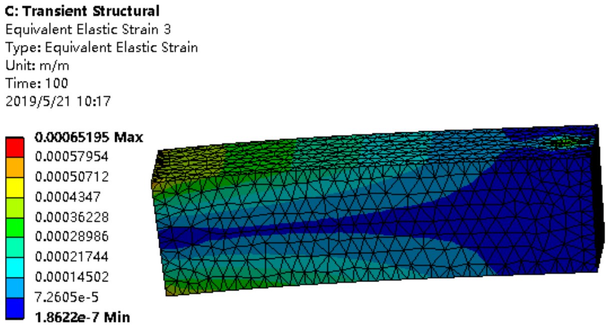

Figure 6. Strain cloud diagram of flexural test

The flexural strain cloud diagram shown in Figure 6 shows that the strain in the middle part is small and the strain on both sides is relatively large. In order to further understand the changes of the specimen under the action of continuous pressure, the stress-strain curve of a and b in the specimen is monitored, As shown below：

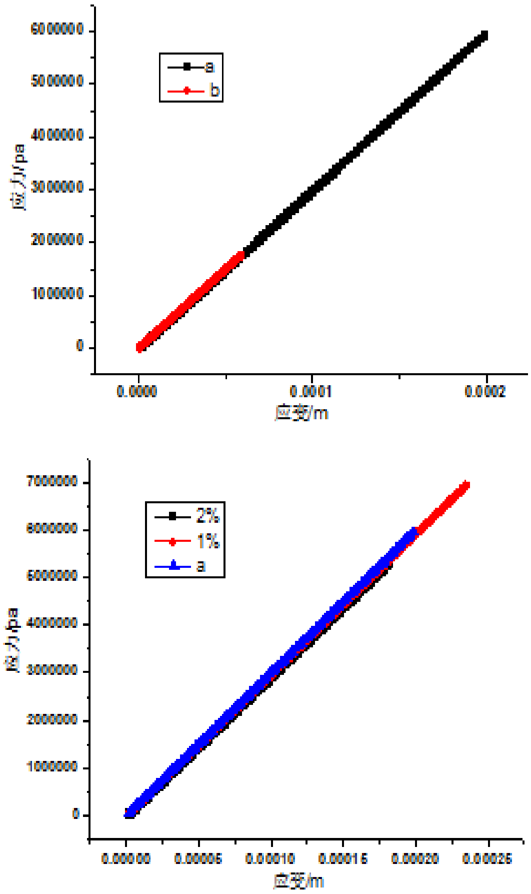

Figure 7. The stress-strain curve of the monitoring point under the 1% dosage of the flexural test and the stress-strain curve of the same monitoring point with different dosages.

It can be seen from Figure 7 that the stresses experienced by the monitoring points of the same specimen may be different, but the stress-strain curves are basically the same. At the same time, the same monitoring point is selected for the different content of concrete, and it can be found that the concrete specimens with different fiber content are The change in flexural resistance is not obvious.

IV. DISCUSSION

The study found that the concrete with different fiber content showed different mechanical properties, while the mechanical properties did not show a certain relationship, and at the same time, there was no reinforcement in the direction of flexural strength, which is basically the same as that of Li Jingjun and Wang Jianchao [12-16] The research results are similar, mainly due to the structure of concrete itself. In the theory of compound mechanics, carbon fiber concrete is regarded as a fiber-reinforced system. The stress, elastic modulus and strength of carbon fiber concrete are calculated based on the mixing principle. According to the distribution and orientation of the fiber in the fiber matrix, the fiber direction coefficient is introduced, and the correct selection of the fiber direction coefficient is one of the main factors that determine the fiber reinforcement effect. In the theory of fiber spacing, it is based on the principle of linear elastic fracture mechanics to explain the effect of fibers on the generation or suppression of concrete cracks. Concrete is a brittle material. Therefore, if you want to enhance its mechanical properties such as bending resistance, compression resistance, and tensile resistance, you should start with the fiber distribution direction. After carbon fiber is added in multiple directions, the viscous stress between the fiber and the two sides of the concrete crack will affect the cracked concrete. Expansion has an inhibitory effect and increases its power.

V. SUMMARY

In this paper, the following conclusions can be reached by analyzing the compression test and flexural test of concrete with different fiber content:

(1) In the compressive test: when the fiber is added, the compressive performance of the concrete shows an enhanced effect, but the fiber content continues to increase and there is no better effect, so the addition of fiber to the concrete will have a peak.

(2) In the flexural test: the effect of the concrete specimen after adding the fiber is the same as the flexural effect of the fiber-free concrete specimen, so the carbon fiber cannot enhance the flexural resistance of the concrete.

(3) In order to analyze the reinforcement mechanism of fiber concrete, the fiber distribution direction should be considered and the discrete element method should be used to further study its mechanism.

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