Study on Mechanical Properties of PVA Modified Cement-based Composites Mixed with Silane Emulsion after Temperature Effect

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Abstract: This article analyzes the basic performance of PVA modified cement-based composite materials, including mechanical properties, durability, and interface bonding issues. The purpose of this article is to clarify the mechanical properties of the modified material and lay the foundation for further optimization of the material ratio. Therefore, the main points of preparation of PVA modified cement-based composite material mixed with silane emulsion in this paper include testing raw materials, design of material mixing ratio, processing of specimen forming process, determination of slump of materials, pouring and maintenance of specimens, etc. the study. And through the study of the material's flexural strength, load-displacement curve, material's compressive strength, material's toughness index, splitting tensile strength, specimen failure form and other mechanical properties analysis.

1. Introduction

The concrete material that has been poured is sometimes subject to external loads and internal stresses, and sometimes there will be some disease problems that directly affect the service life of the structure. Therefore, in order to improve the overall performance of concrete materials, we need to add additional materials to it. In addition, in the process of optimizing the treatment of PVA modified cement-based composite materials, we can add silane emulsion to improve the material's workability and toughness, thereby playing a role in enhancing the comprehensive performance of the material.

2. Basic Performance Analysis of PVA Modified Cement-based Composites

2.1 Mechanical Properties

PVA was added to the cement-based composite material, and its bending performance was analyzed. It was found that the addition of PVA significantly improved the basic properties of the raw materials. In the evaluation process, the orthogonal test method was used to compare the quality of the modified material. The experimental group added the amount of PVA material added, the length of PVA material, the total amount of water reducing agent used, and the water-cement ratio of the material. Besides, another set of control groups is prepared and mixed for the original ratio. According to the experimental data, it can be found that the flexural strength of the composite material increased by 25% after adding the PVA material compared with the control group experiment. In addition, the early compressive strength of the material has also been improved by 15%, indicating that the mechanical
properties of the cement-based composite material after modification have been significantly improved [1].

2.2 Durability
PVA (Polyvinyl Alcohol), as a fiber reinforcement with relatively low difficulty in obtaining, can be fully mixed with concrete and mortar and prepared into composite materials in the instrument. PVA is a synthetic organic substance, which contains more hydroxyl functional groups, and the alcoholic organic substance is relatively hydrophilic. Therefore, in the process of mixing, the interface bond between the two after fusion will be relatively low, and the durability will also be reduced by 20%. In a complex environment, it is easy to damage the substrate. At the current stage, we will choose to add silane emulsion to it to adjust the hydrophilicity of the fiber, thereby improving the durability of PVA fiber, its durability can be improved by 15%-35% [2].

2.3 Interface Integration Issues
In addition to the content of the above research, we also need to discuss the interface bonding of the modified PVA cement-based composite material. Referring to the orthogonal test method mentioned in the above section, in the specific treatment process, the researchers will use aminopropyl triethoxysilane, octadecane isocyanic acid, and silane emulsion as treatment materials. According to the data obtained from the experiment, it can be found that the hydrophobicity of the composite material treated with aminopropyltriethoxysilane is 15% higher than that of similar materials. However, the composite material after octadecane isocyanate treatment improved its water retention by 13%-22%. After treatment with silane emulsion, the fiber composite material's water retention decreased by 15%, and the stability of the material was increased by 25%. This shows that after the surface treatment of the material, the impact on the overall strength of the material is relatively low, and we need to combine the actual situation to screen the material [3].

3. Preparation of PVA Modified Cement-based Composite Material Mixed with Silane Emulsion

3.1 Test Raw Materials
In the course of this test, the raw materials and specific parameters used are as follows: (1) Fine aggregate. The fineness modulus of the fine aggregate selected in this paper is between 2.5 and 2.8, and the moisture content of the material is between 2% and 4%, mainly based on river sand materials. (2) Mixing water. The mixing water selected in the experiment is distilled water. (3) Cement material. The strength of the cement material used in this article is between C32.5 and C42.5, and the type is ordinary Portland cement material. (4) PVA material. The specific parameter information is shown in Table 1 [4]. (5) Silane emulsion. The silane emulsion used in this article is a conventional material, which is a white emulsion, and the relevant parameters are selected in combination with the actual situation.

| Index Content | Diameter (μm) | Length (mm) | Elongation (%) | Tensile Strength (MPa) | Density (kg/m³) |
|---------------|---------------|-------------|----------------|------------------------|-----------------|
| Specific Requirements | 35-45 | 10-13 | 6.5-7.2 | 1500-1700 | 1.3-1.5 |

3.2 Material Mixing Ratio Design
According to the previous construction proportioning experience, when the hydration reaction of cement material occurs, the amount of water required is between 20% and 25%. However, in the mixing stage, a large amount of water is added to ensure the fluidity of the material. At the same time, considering the hydrophilicity of the PVA material, the water-cement ratio also needs to be controlled above 0.7, and the addition amount of the PVA material should be controlled between 0.05% and 1.5%
to stabilize the basic easiness of the material. However, the amount of silane emulsion added is controlled between 0.5% and 2.5%, and the best mixing ratio range needs to be determined through experiments [5].

3.3 Processing of Test Pieces
In the process of forming the test piece, we will choose a self-falling concrete mixer to complete the mixing experiment. In the mixing process, dry mixing will be selected first (time is controlled at about 1min), and water will be added after the materials are evenly mixed (single mixing time is 2min), thereby improving the reliability of the mixing result. In addition, always pay attention to the mixing situation in the mixer and control the mixing speed of the materials to avoid the occurrence of agglomeration and agglomeration of the materials [6].

3.4 Material Slump Determination
Wet the slump cylinder and other utensils with water, and place the cylinder on a horizontal steel base plate that does not absorb water, and use your feet to step on the foot pedals on both sides to keep the cylinder in the same position during the slump test. The specific steps are as follows: (1) The concrete sample after mixing is divided into three times with a small spatula and evenly loaded into a standard conical cylinder. Each layer is inserted and tamped 25 times with a tamping rod until it is compacted. Its height is three around one-half. The tamper should be inserted clockwise from the outside to the center, and evenly distributed. The tamper should penetrate the entire depth and penetrate this layer to the next layer. The concrete on the top layer should be 2cm more than the mouth of the barrel. After the top layer is inserted, the remaining concrete should be scraped clean and smoothed with a spatula [7]. (2) After removing the concrete from the bottom plate of the cylinder, lift the slump cylinder vertically and steadily. The whole process should be completed within 4-8s. The whole process from the beginning of feeding to the lifting of the slump cylinder should not exceed 160s. (3) After the slump cylinder is lifted, the concrete mixture will slump downward due to gravity. Measure the size between the height of the cylinder and the highest point of the concrete specimen after slump, which is the concrete slump. While performing the slump test, observe the cohesiveness and water retention of the concrete mixture in order to comprehensively assess the workability of the concrete mixture. If collapse occurs, re-sampling and testing should be carried out according to the specifications. If the situation still occurs for the second time, it means that the concrete has poor workability and should be recorded for future reference.

3.5 Pouring and Curing of Test Pieces
During the casting operation of the test piece, it is divided into two times, the equal amount of mixing material is poured into the mold that has been supported, and the material is mixed evenly by artificial vibration. At the same time, the iron rod is used to insert and ram in a clockwise manner, and the material is vibrated evenly. Moreover, we need to ensure the filling degree of the pouring material, and release the internal air by tapping and testing the mold, and place it on the vibrating table to vibrate for 1min, so as to improve the compactness of the material. In the curing stage, we should put the materials that have been poured into the room temperature environment for two hours, and use the demoulding machine to remove the mold. Besides, at the same time, do the numbering work, put it into the curing room for a period of time, and then perform mechanical performance tests according to actual needs [8].

4. Research on the Mechanical Properties of Modified Materials

4.1 Material Flexural Strength
The test process requires the test piece and the machine to remain parallel. After the circular column shaft on the testing machine comes into contact with the surface of the test piece, it starts to apply pressure at a loading rate of 50N/s±10N/s. At the same time, manufacture different processing temperatures until the test piece breaks, record the correlation data at this time, the statistical results are shown in Figure 1. According to the data shown in the figure, it can be understood that the modified PVA cement-based composite material has high temperature resistance, and the flexural strength of the material below 150°C will not be attenuated, and has a strong stability [9].

4.2 Load-displacement Curve

The statistics of the load-displacement curve can intuitively reflect the specific situation of the material bending deformation under different load states. As shown in Figure 2, a total of three groups of experiments are planned to be built. In addition to the initial modified treatment group, there are also a control group and an unmodified treatment group. According to the information shown in the figure, the maximum value of the displacement curve of the treated PVA cement-based composite material is significantly higher than that of the other two groups, which also means that the flexural strength of the modified material has been significantly improved. At the same time, according to Fig. 1, it can be known that PVA material has strong temperature resistance, which also means that the material has a strong load bearing capacity and a strong application value in a conventional environment [10].
4.3 Material Compressive Strength

In the material compression experiment, the test piece is placed on the working platform, and different loads are added to it. At the same time, combined with temperature changes, the corresponding parameter information is obtained. The specific statistical results are shown in Figure 3. It can be seen from the figure that the maximum value of the compressive strength of the treated PVA cement-based composite material is significantly higher than that of the other two groups, which also means that the compressive strength of the modified material has been significantly improved. Moreover, under the influence of different temperatures, the added silane emulsion will not affect the material properties, and has strong application value.

4.4 Material Toughness Index

![Figure 4 Schematic Diagram of Toughness Index](image-url)
According to the relevant test, a schematic diagram of the material toughness index is obtained. As shown in FIG. 4, under the effect of different temperatures, the change in toughness of the PVA cement-based composite material with silane emulsion is relatively small. However, after being affected by temperature, the toughness of other experimental groups also declined rapidly, and the decline was directly connected to the amount of material added. It can be seen from this that the treated PVA cement-based composite material has high stability in terms of toughness.

4.5 Splitting Tensile Strength

Carrying out the split-tensile strength test of the material, we obtained the test results in Figure 5. It can be seen from the figure that in the three groups of experiments, the cleavage strength of the control group is the lowest, while the value of the unmodified group is similar to that of the control group. The PVA cement-based composite material after treatment has a maximum cleavage strength that is significantly higher than that of the other two groups, which also means that the modified material's flexural strength has been significantly improved (8.6%).

4.6 Specimen Failure Mode

In addition to the above analysis contents, this paper also analyzes the failure form of the specimen under different temperature environments. As shown in Figure 6, after the modified composite material was subjected to external destructive forces, although many cracks appeared in the structure, the internal PVA fibers began to be stressed, delaying the further cracking rate of the material. Besides, the material is more resistant to different temperatures, but the resistance will continue to decrease as the load increases, until it is finally destroyed.

5. Conclusion

In summary, currently there are certain limitations due to cement-based composite materials. The use
of cement-based composite materials in bridges, roads, etc. is often due to the shortcomings of low tensile strength and poor toughness, resulting in poor road surface quality, short service time, and easy cracking, collapse, and gap formation. Through the above test analysis results, it can be understood that the PVA modified cement-based composite material can be used as the base material. At the same time, it is treated with silane emulsion, which can effectively improve the basic performance of the material and extend the service life of the material after application.

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