

# Study on Cement Matrix Composites Mixed with Graphene Oxide and Silicon Powder and Its Mechanical Properties

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**Keywords:** Graphene oxide, Silica fume, Cement-based composites, Mechanical property.

**Abstract:** Graphene oxide, silica fume and cement-based composite materials as new materials of concrete can improve the strength and compressive strength of concrete. However, the production of graphene oxide and silicon powder is difficult and the quality is difficult to control, which makes the production of concrete more difficult. Based on the study of mechanical properties, this paper explains the composition of cement-based composites by analyzing the content of graphene oxide and silicon powder, and discusses the problems arising in the composition process. From the point of view of graphene oxide and silicon powder, the strategy of optimizing the preparation of cement-based composites by mixing graphene oxide and silicon powder was put forward. It is hoped to provide some reference for the improvement and optimization of cement-based composites.

## 1. Research background

### 1.1 Literature review

At present, few scholars have studied the preparation of cement-based composites and mechanical properties by adding graphene oxide and silicon powder. Huo Junfang, Zhang Shaoyu and others have studied and analyzed the anti-mixing performance of limestone powder in concrete so as to study a strength value of concrete at different ages(Huo et al,2016). Wang Qin and Wang Jian studied the influence of graphene oxide on the micro-study and mechanical properties of cement stone at different dosages. Through a series of standard experiments such as SEM, they studied the morphological characteristics of cement stone, the compressive strength of cement under different conditions and so on(Wang et al,2015). So as to provide relevant reference and guidance for the study of mechanical properties. Pan Xiaoyan studied the preparation of graphene oxide by improved Hummers method. The GO structure was also characterized by XRD and other micro-Characterization techniques(Hua et al,2018). Therefore, under a certain condition, the change of GO content makes the cement-based composites have various mechanical and electrical properties. Li Xianming studied graphene oxide and carbon fibre, then mixed them with cement composite materials to prepare. Then, the mechanical properties of GO-CF cement composite materials and the bonding between reinforcement phase and cement interface were studied by electronic universal testing machine(Li,2018).

### 1.2 Purpose of research

Concrete is widely used in all walks of life. With the different ages, the forms of concrete are also different. Graphene oxide and silica fume have also been used to prepare cement-based composites in the current concrete production process. Graphene oxide, silicon powder and mechanical properties are inextricably linked, and have been used in the preparation of graphene and cement matrix composites. Although graphene oxide and silicon powder are widely used in concrete at present, and cement-based composite materials are also necessary materials for concrete construction, they still face a series of problems that need to be solved urgently. In view of this, this paper elaborates the relationship between graphene oxide and cement-based composite materials respectively. The problems existing in the process of concrete production, such as high brittleness and quality, are summarized. On the basis of mechanical properties, the strength and compressive strength of GO and silica fume are strengthened in order to provide more references for the

preparation of cement-based composites with graphene oxide and silica fume in the process of concrete composition.

## **2. Characteristics of Cement-based Composites Mixed with Graphene Oxide and Silicon Powder**

### **2.1 Characteristic of graphene oxide**

Graphene is a two-dimensional carbon nano-material with honeycomb lattice, and its constituent elements include carbon atoms. Graphene is widely used because of its great advantages in optics, electricity and mechanics. And it has very important application prospects, which is considered by most scholars as a revolutionary material in the future. Graphene oxide, yellow, is the oxidation product of graphene. One of the characteristics of graphene oxide is its solubility and hydrophilicity, so it can exist stably in aqueous solution and solvent. Because it belongs to non-traditional soft materials, it also has the characteristics of colloid and two molecules. There are three main preparation methods of graphene oxide, including Brodie method, Staudenmaier method and Hummers method. Hummers are used more Graphene oxide, as an important derivative, can be widely used in other fields even though it destroys the highly conjugated structure of graphene during oxidation. Graphene oxide has the same physical, optical and electrical properties as graphene oxide because of its optical properties. Therefore, graphene oxide is widely used in the fields of optoelectronics, solar cells and biology.

### **2.2 Characteristics of silicon powder**

Silicon powder, also known as micro-silica powder, the scientific name “silica fume” is a highly effective active admixture. Silicon powder is formed by high temperature smelting of industrial silicon and ferrosilicon in industrial electric furnace, special treatment and collection of smoke and dust from exhaust gas. It is called silicon powder because of its small size and only at the nanometer level. Silicon powder is mainly used in cement, rubber, water glass and other industries, and it has the characteristics of adsorption, but also can be used as adhesives and insulation materials. Silicon fume is currently mainly used in water conservancy, hydropower, highway and construction engineering, such as concrete mixing. Another form of silicon powder is micro-silicon powder, which is mainly used in the electronics and electrical industry.

### **2.3 Characteristics of cement-based composites**

As one of the materials in the process of concrete production, cement-based plays an important role in engineering and construction. Cement-based composites are composites based on Portland cement, reinforced by various high-performance fibers such as synthetic fibers, metal wires and other materials, with fillers, water and other additives. Moreover, in the case of cement-based composite materials, the quality and performance of concrete will be many times higher than that of ordinary. But the production process of cement base is also complicated. It is necessary to control the proportion of related materials and the relative temperature and humidity in the manufacturing process. There are many kinds of concrete, the earliest is the concrete of steel bar in France. Until about 30 years ago, polymer composite concrete and concrete admixtures appeared. Cement-based concrete, as a new material added to concrete at present, has been widely used in various related road construction.

## **3. Problems in Composite Cement-based Composites of Graphene Oxide and Silicon Powder**

### **3.1 High brittleness of cement-based materials mixed with graphene oxide and silicon powder**

Concrete is currently recognized as one of the vulnerable materials. Because the strength of concrete is improved, but the consideration of brittleness is less. In concrete engineering, tension-compression ratio is one of the criteria to measure its vulnerability, and the smaller the ratio, the greater the brittleness. Considering that graphene oxide and silicon powder are synthesized in

different ways, they are prone to instability, which is also one aspect of brittleness(Chen et al,2018).

Fig. 1 is the most basic silicon oxide tetrahedron structure in hardened cement paste. Because there are crystals in the cement slurry, it will show the characteristics of low elongation and high brittleness in the material. During the hardening process, there will be some small cracks and holes on the orthopaedic surface due to bleeding. Moreover, because heterogeneity and voids are the characteristics of concrete, local stress concentration and vulnerability damage will occur when concrete is subjected to load.

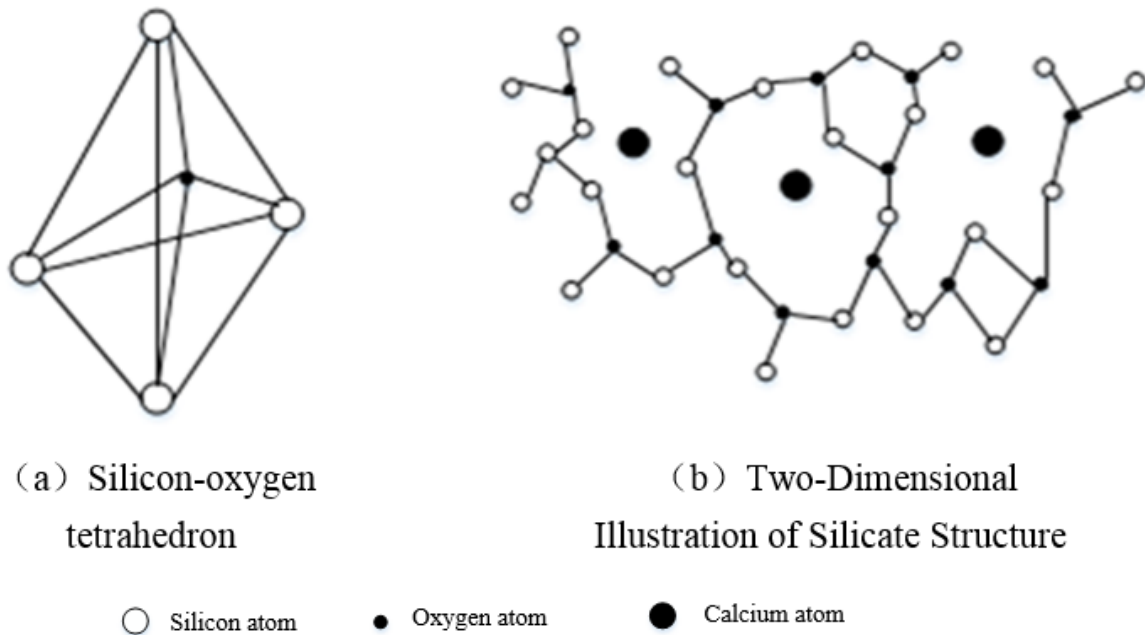


Fig. 1 The original structure of silicon-oxygen tetrahedron in hardened cement paste

### 3.2 The quality of graphene oxide and silicon powder is difficult to control

First of all, graphene oxide. Firstly, it is difficult to extract graphene because graphene is prone to explosion during oxidation. The oxidation process is good or bad for graphene refining, so it is very important to test the strength of the experimenters. Second, graphene oxide costs more. When graphene is converted to graphene oxide, the oxidation process is complex and the cost is high. So one of the phenomena is that graphene oxide can not be produced continuously. Moreover, poor quality graphene oxide can not guarantee the quality and safety of industry, resulting in the high cost of good graphene oxide can not be mass produced, and almost can not replace the level of existing products. Thirdly, it is difficult to synthesize. Complete graphene oxide without impurities is also difficult to oxidize, its cost performance is low, and its performance is difficult to achieve the desired results(Dang et al,2014).

The second is silicon powder. The main problem is extraction. Silicon powder is obtained by melting at high temperature and collecting dust. It is difficult to control the temperature for the extraction of silicon powder. In addition, collection is also difficult, and if protective measures are not in place, it is easy to lead to the occurrence of related diseases.

### 3.3 The proportion of silicon powder to graphene oxide is difficult to control

It is very difficult to mix graphene oxide and silicon powder to prepare cement-based composites. It is often seen that laboratories have extremely accurate data for the addition of various reagents, so once mistakes are made, it is easy to complete the danger. Graphene oxide and silicon powder are no exception. Especially GO content. On the one hand, it is the construction side. Because the cost of graphene oxide is too high, the builder is greedy for cheaper and less doping, resulting in the uneven amount of graphene oxide doping. On the other hand, the professionalism required is too high. Graphene oxide itself is difficult to extract, so if the amount of doping is not appropriate, it

will cause a waste of resources, unable to ensure the overall quality.

### **3.4 Single preparation method**

At present, Hummers method is commonly used in the preparation of graphene, but the preparation of graphene is relatively simple. Hummers preparation method is better than other methods, but it is difficult to guarantee a success. Moreover, many construction teams seldom use related graphene preparation methods, and the cost can not be controlled. At the same time, it is limited to one preparation method and the time cost is too high. It is not only unfavorable to production, but also easy to cause various troubles caused by failure. In addition, Hummers method is difficult to ensure that graphene is purified(Wang,2015).

## **4. Optimizing Compound Mixing of Graphene Oxide and Silicon Powder to Prepare Cement-based Composites and Its Mechanical Application**

### **4.1 Improving the strength of cement-based composites prepared by compound mixing of graphene oxide and silicon powder**

The strength and durability of concrete are not only related to the quantity and quality of each component, but also affect the strength and brittleness of concrete. Faced with graphene oxide and silicon powder, cement-based materials are prepared to ensure durability and pressure resistance, as well as the length of time. First, mineral admixtures can be added. Fine mineral admixtures have high reactivity, which can not only hydrate cement, but also reduce micro-cracks and defects in cement base. Secondly, fiber reinforced materials. For example, carbon fibers can prevent cracks in concrete and enhance toughness. There are many kinds of reinforcement methods for concrete, including polymer mixing and so on.

### **4.2 Strictly control gO and silicon powder quality**

Compared with silicon powder, graphene oxide is not only difficult to extract, but also easy to produce magazines in the process of refining, resulting in poor quality. Although the process of silicon powder training is relatively simple, the treatment process is also harsh. In a word, as cement-based materials, the quality of both should be strictly controlled. The first method is the choice of personnel, professional and high quality. In addition, he is familiar with the extraction process of the two materials and has rich experience. Secondly, GO content has a profound influence on the mechanical properties of cement-based composites, which can improve the flexural and compressive strength of the composites.

### **4.3 Scientific and intelligent ratio gO and silicon powder doping quantity**

The quality of graphene oxide and silicon powder is the most important, but the proportion of doping is equally important. Artificial experience has a good experience to control the amount of incorporation of the two, but inevitably there will be no error. Therefore, intelligent equipment can be used for data acquisition and extraction at any time. It not only ensures the rational mixing scheme, but also avoids the waste of resources, and also improves the overall quality of cement base. In addition, experimental method can be used to determine a variety of mixing methods. Therefore, in the mixing process, because the mistake causes a certain substance to be mixed more, the mixing proportion can be adjusted by mixing. Thus, the overall effect is better and the quality is ensured without any problems.

### **4.4 Additional preparation methods**

The preparation of graphene by single Hummer method is one of the recognized methods at present. But with the continuous updating of technology and the deepening of scientific intelligence. As a whole, there are more and more methods to prepare graphene. For example, there are a series of methods such as chemical vapor deposition, crystal epitaxy growth, organic synthesis and so on. So for the construction engineering, there are many ways to prepare graphene, and there are many choices. In this way, it not only improves the production speed, but also guarantees the

improvement of quality.

## 5. Conclusion

As an indispensable material in current engineering, concrete is widely used in all walks of life. In this paper, the preparation methods and characteristics of graphene oxide and silicon powder are introduced, and the current development status and application degree of graphene oxide and silicon powder are explained. At the same time, the main contents of cement-based composites are introduced, which can provide reference for the preparation of concrete. In addition, the quality, proportion and method of graphene oxide and silicon powder in the process of blending cement matrix into composite materials were explored. Based on the mechanical research, the relevant countermeasures of how graphene oxide and silicon powder can be better blended into cement base are given.

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