

Study on Mechanical Properties and Application of Magnesium Phosphate Modified Cement

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Abstract. In today's environment, the use of magnesium phosphate cement is more and more extensive, but it still faces problems such as fast setting and brittleness. This paper aims to solve the problem and improve the fire resistance of magnesium phosphate cement by modifying the compound. Through literature search, it is found that the incorporation of vinyl acetate ethylene copolymer emulsion (VAE) and anionic polyacrylamide (APAM) into cement can improve the problem of fast setting time and improve the flexibility of modified magnesium phosphate cement. The glass fiber can increase the bending and compressive strength of magnesium phosphate cement by adding silane coupling agent into cement. The fire resistance of phosphate cement can be greatly improved by using expanded perlite as fire retardant coating. The main research significance of this paper is to solve the shortcomings of magnesium phosphate cement and make the use of magnesium phosphate cement more extensive and safer.

Keywords: Magnesium phosphate cement; Polymer; Dynamics; Fireproofing.

1. Introduction

At present, Portland cement has become the most widely used cement material because of its low price and simple access to raw materials. However, the disadvantage of Portland cement is becoming increasingly prominent, that is, it does not meet the modern needs for environmental protection. Each production of a ton of Portland cement will consume a lot of fuel and emit a lot of carbon dioxide, which undoubtedly greatly increased the burden of human living environment. Another reason that cannot be ignored is that in recent decades, Portland cement can cause cracks because it is used for too long, so people need to find a new type of cement. In this case, phosphate cement was chosen as a suitable repair material because of its advantages such as strong resistance to erosion, resistance to high temperatures (1300 degrees Celsius), and rapid setting. However, it also has the disadvantage of being brittle and relatively high [1].

Phosphate cement is mainly used in the repair of cracks and other work, but because of its fast setting, brittleness and other characteristics, phosphate cement can not be widely used in the repair work. Therefore, this paper studies the phosphate cement by different materials. For example, the addition of polymer emulsion and fiber are modified in two ways to solve its shortcomings such as large brittleness and reduced strength in humid environments. At the same time, the mechanical properties of phosphate cement are studied, mainly in the aspects of compressive performance, durability and fire resistance. Take the characteristics of fire resistance and high temperature, even though phosphate cement is very good for high temperature resistance, it is rarely built with phosphate cement due to its high cost. Therefore, how to reduce the cost under the premise of ensuring the fire resistance of phosphate cement is also a research direction of this paper.

2. Raw Materials of Phosphate Cement

The raw materials of phosphate cement include magnesium oxide and potassium dihydrogen phosphate, but in order to meet the needs of improving its toughness and setting time and fire resistance, polymer vinyl acetate ethylene copolymer emulsion (VAE), anionic polyacrylamide (APAM), silane coupling agent and expanded perlite can be added to the cement preparation process.



2.1. VAE

The first batch of VAE modified magnesium phosphate cement is prepared by adding magnesium oxide, potassium dihydrogen phosphate and polymer according to different specific gravity. VAE were chosen because VAE is often blended with other polymers as a modifier due to its good flexural, toughness, stress cracking resistance and bonding properties. The blends of polyethylene and VAE have excellent flexibility, processability, good gas permeability and printability, so they are widely used. VAE copolymers can withstand high doses of fillers, and can be blended well with different organic or inorganic compounds to prepare composite materials for various purposes or as masterbatch carriers.

2.2. APAM

APAM is a category of polyacrylamide, along with cationic polyacrylamide and non-ionic and complex ionic types. The colloidal product is colorless, transparent, non-toxic and non-corrosive. The powder is white granular. It is more widely used in removing suspended turbidity and sludge concentration and dehydration of industrial water, and sludge concentration and dehydration of industrial and domestic sewage treatment plants; Chemicals for wastewater treatment and filtration, retention and enhancement in paper industry; It is used in metal and mining, food fermentation, product concentration in chemical industry, wastewater treatment and other work.

2.3. Silane Coupling Agent

Glass fiber was added to magnesium phosphate cement and silane coupling agent was selected as the material. Silane coupling agent G-570 is a colorless to light yellow liquid that has low surface tension and high adhesion, allowing stable bonding between inorganic surfaces and organic materials. In addition, it also has good heat resistance, solvent resistance and corrosion resistance. It is widely used in coatings, adhesives, fillers, fibers, plastics and other fields. It can be used as an interface active agent to improve the adhesion and weather resistance of coatings and adhesives. In fillers and fiber reinforced materials, it can play the role of reinforcing agent and surface modifier. In addition, the silane coupling agent G-570 can also be used to improve the adhesion, dispersion and adhesion resistance of plastics.

These three organic compounds were selected as materials to modify magnesium phosphate cement, and their mechanical properties and characteristics such as compressive capacity, tensile capacity, tension ratio and folding ratio were studied to find out what effect different materials had on the modification of magnesium phosphate cement.

3. Physical Properties of Magnesium Phosphate Cement

This chapter mainly discusses the advantages and disadvantages of different organic compounds in modified magnesium phosphate cement by observing the different physical properties of modified magnesium phosphate cement and its performance in compressive resistance and bending resistance. The reason for choosing to study magnesium phosphate cement is that magnesium phosphate cement is one of the most widely used cements.

3.1. Condensation Time

Firstly, the setting time of magnesium phosphate cement was analyzed. For the cement modified by APAM, the setting time of magnesium phosphate cement first increases and then decreases with the increase of APAM content. The analysis shows that APAM will block the cement reaction on the cement surface and reduce the reaction rate because APAM will form a gel after incorporation. The effect of VAE on the setting time of magnesium phosphate cement shows that the setting time will increase continuously. This may be due to the increase of cement fluidity after the addition of VAE and the decrease of the reaction rate due to the emulsion coated on the cement surface [2].

The above is the change rule of setting time of polymer-modified magnesium phosphate cement. Next, the different bending strength and compressive strength of different modified cements will be expounded, and their folding ratio will be analyzed.

3.2. Tension Ratio

Tensile compression ratio is the ratio of compressive stress and tensile strength of concrete under pressure. This index mainly reflects its safety under stress. APAM blended magnesium phosphate cement is less rigid but more ductile than before, probably because APAM filled the gaps in the original magnesium phosphate cement. However, with the increase of APAM filling amount and the extension of setting time, too much APAM filled in the gaps of magnesium phosphate cement, which made its rigidity deteriorate. The influence of VAE incorporation on tensile compression ratio: the folding compression ratio is similar for the same amount of addition, but with the increase of setting time, the folding compression ratio of cement decreases. The analysis shows that early addition of VAE can reduce the water products in magnesium phosphate cement and fill the interior of the emulsion film, which makes the cement adhesion enhanced. But over time, the water product is too low, although there is an internal emulsion film acting as a network structure, which makes it more flexible.

3.3. Folding Ratio

Folding ratio is the ratio of compressive stress and folding strength of concrete under pressure. This index mainly reflects its safety under stress. The incorporation of APAM into the magnesium phosphate cement will increase its internal filamentous structure, which improves the brittleness of the magnesium phosphate cement and increases the flexibility of the cement, which makes the cement more complete when subjected to stress breaking. VAE has a good film-forming form, so it encapsulates the reactants after incorporation of magnesium phosphate cement. Moreover, because of the VAE film formation, it plays a certain connectivity, which can cause the magnesium phosphate cement to be damaged but not broken. It can be found that these polymers can improve the rigidity of magnesium phosphate cement and thus strengthen its folding ratio. VAE is superior to APAM in comparison. Both of these two polymers can increase the internal adhesion of cement and increase the plasticity of cement. However, due to the different film forming types of these two polymers in cement, the better film forming type will have a greater impact on cement.

3.4. Flexural and Compressive SStrength

Next, the performance of magnesium phosphate cement mixed with glass fiber in compressive strength and flexural strength was analyzed. To study the performance of modified cement in flexural strength, it is necessary to apply the Eq. 1.

$$f = 3FL/2bh^2 \quad (1)$$

where f is the flexural strength, F is the load limit, L is the manufacturing distance, b is the width of the specimen, and h is the height of the specimen. For compressive strength, Eq. 2 is used:

$$S = F/A \quad (2)$$

where S is the compressive strength, F is the maximum load applied to the specimen, and A is the compression area [3].

The sample adding glass fiber to the folding strength can increase the folding strength, and the folding strength will increase with the increase of the amount of incorporation. However, according to the data, only low content of glass fiber can increase the bending strength of magnesium phosphate

cement at all ages. With the increase of glass fiber content and length, the flexural strength of magnesium phosphate cement will decrease, possibly because the toughness of cement will decrease when the content of glass fiber is too much. The influence of glass fiber on the compressive strength of magnesium phosphate cement is basically the same as the bending strength. At low dosage, the compressive strength of cement increases as the dosage increases slowly. However, the influence on the compressive strength of cement is not obvious when the dosage is too much [4].

3.5. Fire Resistance

Although the modification of magnesium phosphate cement has achieved success in mechanical properties, there are more problems than these in actual life, as well as some problems such as freeze resistance and heat resistance of magnesium phosphate cement. Because cement is the most common material in residential buildings, its heat isolation ability is even as important as its mechanical properties, so the modification of magnesium phosphate cement can not be stopped. Through searching the literature, it is found that adding expanded perlite can make high quality fireproof materials. Perlite this material is a volcanic eruption of acidic lava after the rapid cooling of the formation of glassy rock, with pearl fracture structure, brittle, pearl luster and grease luster. Commonly used in rubber and plastic products, pigments, paints, inks, synthetic glass, heat insulating bakuka and some mechanical components and equipment as filler. Perlite has been expanded to become a new lightweight, multifunctional material. It has the characteristics of light weight, low thermal conductivity, strong sound absorption, good chemical stability, wide temperature range, small moisture absorption capacity, and non-toxic, tasteless, fireproof, sound absorption and so on. As a fireproof coating, expanded perlite can be said to be better than some current fireproof coatings, because expanded perlite is a porous structure. Therefore, it can store a part of water in small pores, which increases the water content of the modified magnesium phosphate cement and thus increases its fire resistance [5].

4. Conclusion

This paper mainly studies the different physical properties of magnesium phosphate cement modified by different substances, and the research results are as follows:

(1) Different substances have different properties. VAE has good flexural, toughness, stress cracking resistance and bonding properties. APAM's colloid is colorless, transparent, non-toxic and non-corrosive. The powder is white granular. Silane coupling agent G-570 is a colorless to light yellow liquid that has low surface tension and high adhesion, allowing stable bonding between inorganic surfaces and organic materials.

(2) With the continuous improvement of magnesium phosphate cement, the properties of cement are constantly changing. From the point of view of setting time, the setting time of cement added with polymer is increased. The mechanical properties of the modified magnesium phosphate cement are also changed compared with those before modification. The cement added with APAM shows that there are many more filaments inside the cement due to the addition of APAM. Therefore, the tensile compression ratio is lower, and the integrity is formed when crushed by folding. The cement mixed with VAE forms a network structure in the interior, so that the tensile pressure ratio is increased, and it breaks continuously when crushed. The flexural strength and compressive strength of magnesium phosphate cement with glass fiber were changed. When the initial amount of glass fiber is small, the compressive strength and flexural strength will increase. When the amount of glass fiber is too much and the curing time is increased, the flexural strength of cement will decrease and the compressive strength will not change much. The cement with expanded perlite has increased fire resistance due to the moisture in the internal voids.

(3) There are many mechanical properties not studied in this chapter, such as bending toughness, impact toughness. Modified magnesium phosphate cement is not perfect enough, so it is necessary to make continuous attempts to modify magnesium phosphate cement in the future.

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