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Study on the effect of fly ash on the properties of potassium magnesium phosphate cement

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ABSTRACT

In this paper, the effect of fly ash on the setting time and mechanical properties of potassium magnesium phosphate cement was studied. The early hydration process of potassium magnesium phosphate cement was studied by TAM-Air, and the hydration products were analyzed by XRD. The results showed that fly ash can effectively prolong the setting time and the compressive strength of the cement paste was decreased; The addition of fly ash would not change the phase composition of the hydration products of the potassium magnesium phosphate cement, which affect the hydration process, the amount of the hydration products and the degree of crystallization of the cement.

1. INTRODUCTION

Magnesium phosphate cement (MPC) is a new type of air hardening cementitious material, which is composed of dead-burned magnesium oxide, phosphate, retarder and a certain proportion of admixture.[1]. MPC has the advantages of rapid hydration, high early strength, wide environmental adaptability, small volume deformation, high bond strength, good wear resistance and frost resistance. In recent years, MPC has been widely used in rapid repair, rapid reinforcement, outburst prevention technology and solidification of harmful substances and national defense engineering construction.[2]. However, MPC releases a lot of heat in the construction process, accelerates the hydration of MPC, shortens the setting time, reduces the construction operability, increases the construction difficulty, increases the temperature stress, easily causes temperature cracks, reduces the cement performance and becomes the building structure of MPC hidden danger. Adding a certain proportion of mineral admixture in application not only reduce the cost, it can also improve the performance of MPC.[3]. At present, fly ash (FA) is widely used in cementitious material as a cheap admixture.[4, 5]. In this paper, FA is selected as the active mineral admixture to study the effect of FA on the setting time and mechanical properties of MPC, the early hydration process is studied by TAM-air, and the hydration products are analyzed by XRD, in order to provide a useful reference for the promotion and application of MPC.

2. EXPERIMENT

2.1 Materials

Dead-burned magnesium oxide (MgO) and FA were supplied by Shenyang, the chemical composition of MgO and FA were shown in **Table 1. and 2.** Potassium dihydrogen phosphate (KH_2PO_4), white crystal, industrial grade. The retarder is borax ($Na_2B_4O_7{\cdot}10H_2O$), white crystal, industrial grade. The experimental water is tap water.

Table 1. Chemical composition of MgO /%

MgO	SiO_2	CaO	Al_2O_3	Fe_2O_3	Other
93.61	2.32	1.81	0.93	0.82	0.5

Table 2. Chemical composition of FA /%

SiO_2	Al_2O_3	Fe_2O_3	Na_2O	P_2O_5	MgO	CaO	Loss
57.03	29.31	4.84	0.41	0.63	0.55	0.89	0.55

2.2 Methods

In the experiment, the ratio of magnesium to phosphorus is 6:1, the ratio of water to cement is 0.2:1, the content of borax is 3% of MgO, the content of FA instead of MPC is 0%, 5%, 10%, 15% and 20%, respectively. Determination of setting time, the initial setting time and final setting time of MPC paste refer to “the test method for water consumption, setting time and soundness of cement standard consistency” (Chinese standard

GB/T 1346-2001). Measurement of mechanical properties, the test piece size of mechanical properties of cement mortar is 40 mm × 40 mm × 160 mm. The specimen is formed and is cured in air for 28 days, and the compressive strength of MPC mortar according to “the test method for strength of cement mortar” (Chinese standard GB/T 17671-1999). The hydration heat release process was analyzed by TAM air (8 channels) hydration calorimeter, and the composition of hydration products was analyzed by Rigaku D/MAX-IIIC type X-ray diffractometer.

3. RESULT AND ANALYSIZE

3.1 Setting time

Table 3 shows the effect of FA on the setting time of MPC. It can be seen from **Table 3.** that FA shortens the setting time of MPC, the setting time first increases and then decreases with the increase of FA content. The main reason is that FA partially replaces MgO in the MPC, which reduces the content of MgO in the system and prolongs the setting time of MPC. However, with the content of FA increase, FA occupies the dominant position on the surface of MgO, the adsorption of MgO to retarder was reduced, thus shortening the setting time of MPC.

Table 3. Effect of FA on setting time of MPC

FA content (%)	0	5	10	15	20
Setting time (min)	29	32	34	37	30

3.2 Mechanical property

Figure 1. shows the effect of FA on the c ompressive strength of MPC at 28d age c uring. It can be seen from Fig.1 that the compressive strength of MPC decreases with the content of FA increase. The decr ease is not obvious when the dosage is l ess. When the content of FA was more t han 10%, the compressive strength decre ased obviously. The compressive strength is 44 MPa at the moment, 4% lower tha n the control group. When the content of FA was 20%, the compressive strength d ecreased to 29.7% of than the control gro up. The reason for the decrease of compr essive strength is that the content of MPC and produces were reduced with the add ition of FA. The strength loss effect plays a leading role in the reduction of hydratio n products, so the strength will decrease t o a certain extent.

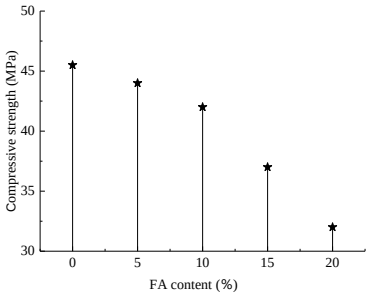

Figure 1.Compressive strength of MPC with different FA content at 28 day

3.3 Hydration heat

It can be seen from **Figure 2.** that the hydration exothermic peak of MPC appears after a period of hydration reaction. With the addition of FA, the hydration exothermic peak of MPC paste appears slightly later. The results show that the hydration heat of MPC decreases with the addition of FA. This result is consistent with the effect of FA on setting time. The metal cations on the surface of FA particles can adsorb the phosphate ion in the slurry, delay its adsorption on the surface of MgO particles, the setting process of MPC was affected. At the same time, there are a lot of fine glass beads in the FA, whose morphology is complete and the surface is smooth. It has a very good lubricating effect, plays a certain role in reducing water in the system, indirectly increases the water binder ratio of the slurry, and prolongs its setting time.

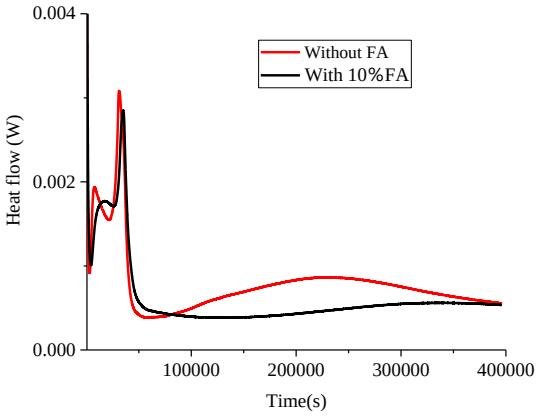

Figure 2. Hydration heat release rate of MPC

3.4 Hydration production

The sample with 10% FA and without FA were showed in **Figure 3.** It can be seen

from Fig. 3 the main hydration products were $MgKPO_4 \cdot 6H_2O$ and MgO. With the addition of FA, the types of the main hydration products of MPC did not change, which indicated that the addition of FA would not change the types of the main hydration products of MPC. The diffraction peak intensity of has changed, indicating that the addition of FA will affect the crystallization degree. FA remains between hydration products, which blocks the continuity of hydration products.

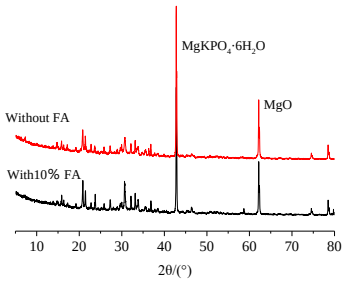

Figure 3. Hydration production of MPC

4. CONCLUSION

(1) The setting time of MPC first increases and then decreases with the addition of FA greatly.

(2) The compressive strength of MPC decreases with the content of FA increase. When the content of FA was 10%, the compressive strength decreased to 4% of than the control group.

(3) The hydration process of MPC was delayed with the addition of FA, the main types of hydration products of MPC can not change.

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