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The influences of two admixtures on white and colored Portland cement

Chang Jun*, Cheng Xin, Lu Lingchao, Liu Futian, Zhu Jianping

Department of Materials Science and Engineering, Jinan 250022, China

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Abstract

This paper studies the influence of two admixtures on white and colored Portland cement. The results show that the compressive strength of the white Portland cement is improved when the proper quantity of the admixtures is mixed, and the white degree of the white Portland cement is obviously not influenced. In addition, the cost of the white Portland cement is reduced and the color of the colored Portland cement is ameliorated. Through the experiment, the optimal quantity of the admixtures is found. The hydration mechanism of the cement and the reason of improving color are discussed by XRD, TG, SEM and so on. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: White Portland cement; Colored Portland cement; Admixture; Hydration mechanism

1. Introduction

White Portland cement produces more $Ca(OH)_2$ in hydration, which results in alkalization and carbonization, color aging on the surface of colored Portland cement and concrete [1]. In this experiment, alkalization of white Portland cement and the color of colored Portland cement are improved through mixing some admixtures. In addition, the strength is raised and the cost is reduced. The purpose is acquired.

2. Experimental

2.1. Raw materials

The 425# white Portland cement of Shuangji group in Shandong and white admixture L and K (industry wastes) are used. The chemical composition of the two admixtures are listed in Table 1.

2.2. The influence of admixtures on the white cement strength

The experiment uses a $2 \times 2 \times 2$ cm^3 mould according to the ratio of water/cement = 0.35. These specimens are demoulded after being cured in moist air at 20°C for 1 day, then the specimens are cured in water at 20°C to

Table 1
The chemical composition of two admixtures

	Chemical composition (%)					
Admixture	Loss	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO
K	0.63	32.46	0.97	13.61	45.65	4.29
L	12.66	72.50	1.35	10.08	1.36	0.39

Table 2
The compressive strength of white Portland cement with different quantity admixture (MPa)

		The quantity of admixture (%)						
Admixture	Time	0	5	10	15	20	25	30
K	3 days	15.0	17.9	17.9	13.7	11.6	12.3	10.5
	7 days	22.2	17.8	20.0	19.1	17.4	18.2	15.1
	28 days	31.6	55.7	39.9	33.7	40.7	28.1	33.6
L	3 days	15.0	24.3	19.3	22.5	15.3	14.4	11.8
	7 days	22.2	27.6	22.9	26.4	23.6	28.4	26.2
	28 days	31.6	33.7	28.7	36.9	32.8	34.1	36.1

Table 3
The white degree of the white Portland cement with different quantity admixtures

Admixture	5%	10%	15%	20%	25%	30%
K	82.8	82.6	82.1	80.2	79.1	77.0
L	82.5	82.4	82.3	81.8	72.8	73.1

* Corresponding author. Tel.: +86-531-797-4453.
E-mail address: mlchang@etang.com (J. Chang).

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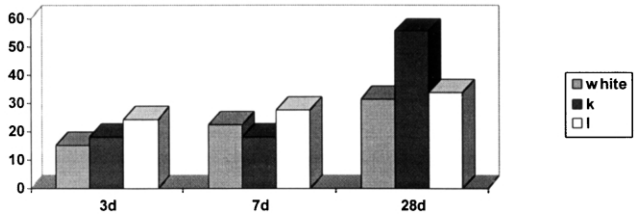

Fig. 1. The compressive strength of the cements.

each age for measurement of the compressive strength. The results are listed in Table 2.

2.3. The influence of admixtures on the white degree

The white degree of white Portland cement and K and L admixtures are 82.3, 81.6 and 79.4. The white degree is determined by the ZBD type white degree instrument in which the white degree of MgO is 100 as a standard. When the white cement is mixed with different quantities of admixtures, the white degrees are listed in Table 3.

From Table 3, we can see that the influence of admixtures on the white degree is unconspicuous.

2.4. The influence of admixtures on the colored Portland cement's color

By the way of observing the color change and surface alkalization, some color bricks are made. First, the white Portland cement is mixed with some paints as 1%, 3% and 5% [3]. Second, half of them are mixed 5% admixtures. Then these cements are mixed with 10% water and pressed to bricks. The bricks are cured in moist air at 20°C for 1 day. The color and alkalization of them are compared on 1 day, 7 days, 28 days and 1 year. The result shows that the color of the cement with admixtures is more vivid than the pure colored Portland cement, and the surface of the bricks made by pure colored Portland cement is alkalized and the color is aged.

3. Analysis and discussion

3.1. The optimal quantity of admixture

Considering the white degree and compressive strength of the white Portland cement with the admixtures, the optimal quantity of two admixtures is 5%. The compressive strengths are listed in Table 2 and Fig. 1.

3.2. The hydration mechanism analysis of the white Portland cement with admixtures

3.2.1. The XRD analysis

The XRD patterns of the white Portland cement in different ages are in Fig. 2. It shows that the main products of the hydrated samples of the white cement are $Ca(OH)_2$, AFt, hydrated calcium aluminum and unhydrated calcium silicate. The approximate quantity of the hydrated products can be judged from the height and width of diffraction peaks. The peaks of $Ca(OH)_2$ are higher along with the hydration age in white Portland cement hydration products, but they are shorter along with the increasing of age in white Portland cement with L and K admixtures. This shows that L and K admixtures can restrain $Ca(OH)_2$ effectively.

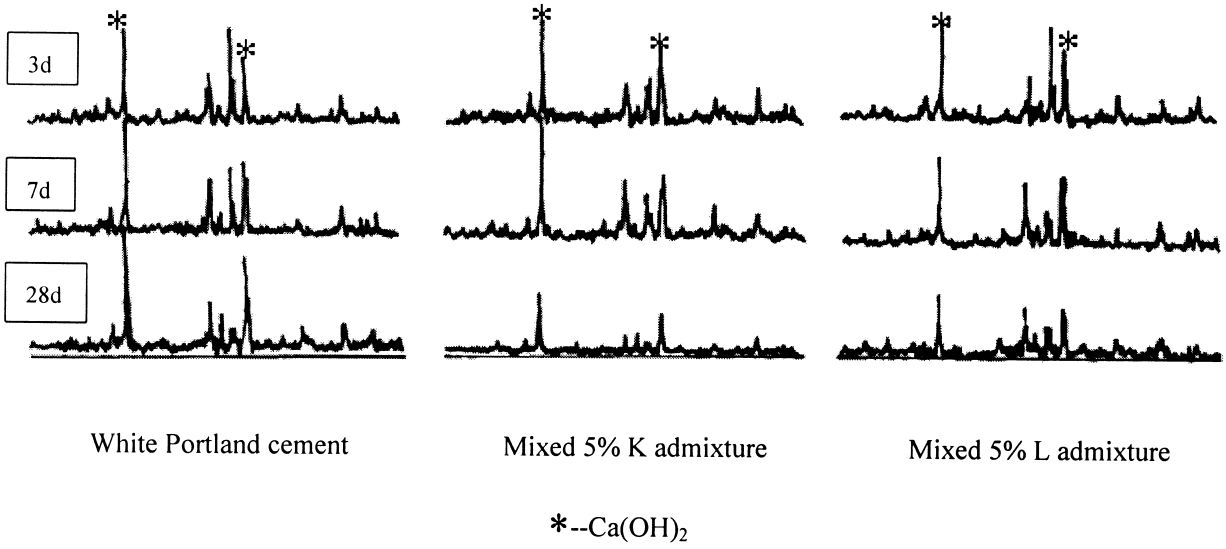

Fig. 2. The XRD patterns of hydrated samples.

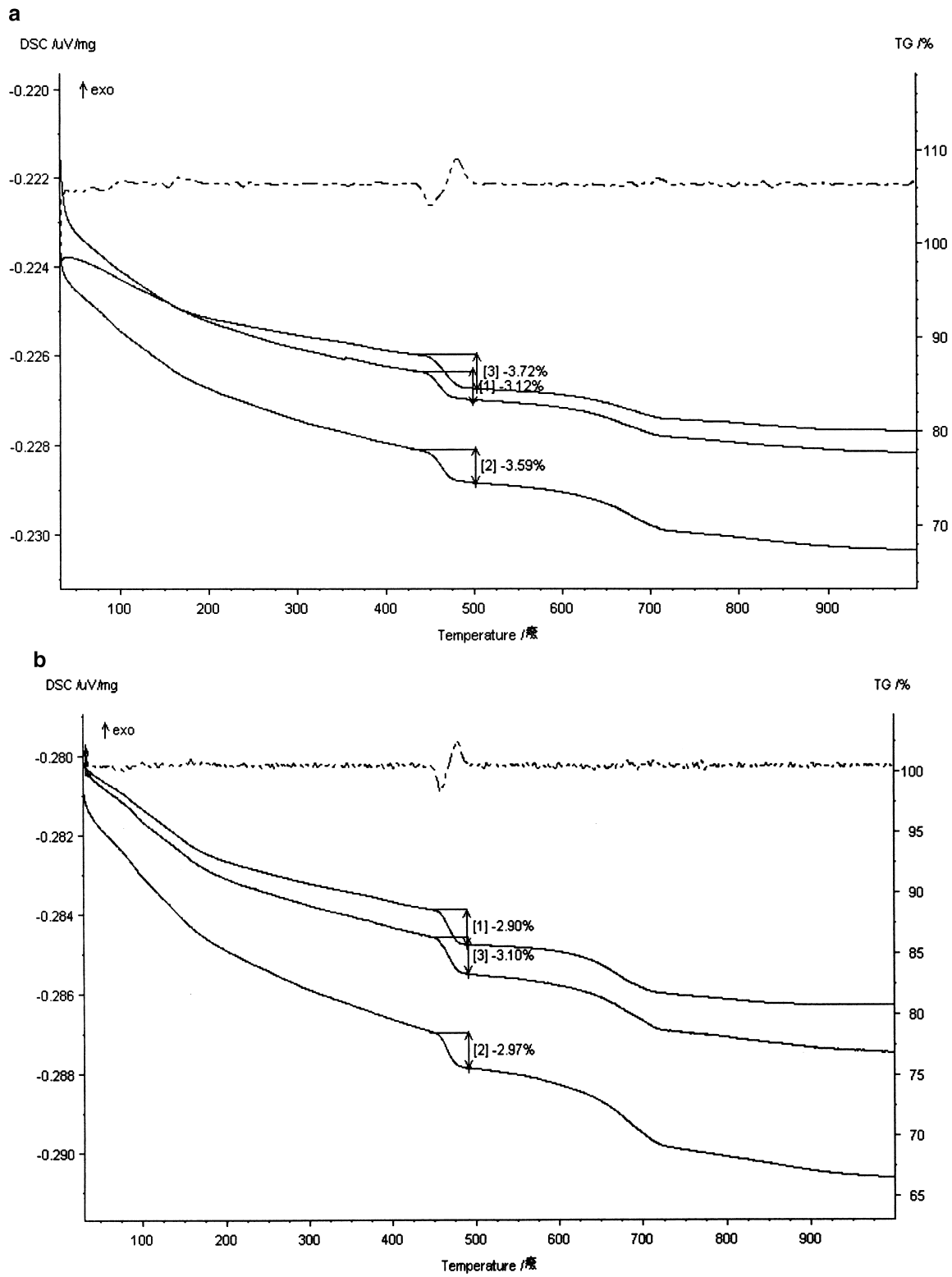

Fig. 3. The TG-DSC pattern of the hydrated samples. (a) The TG pattern of white Portland cement. (b) The TG pattern of the white Portland cement with 5% K admixture. (c) The TG pattern of the white Portland cement with 5% L admixture.

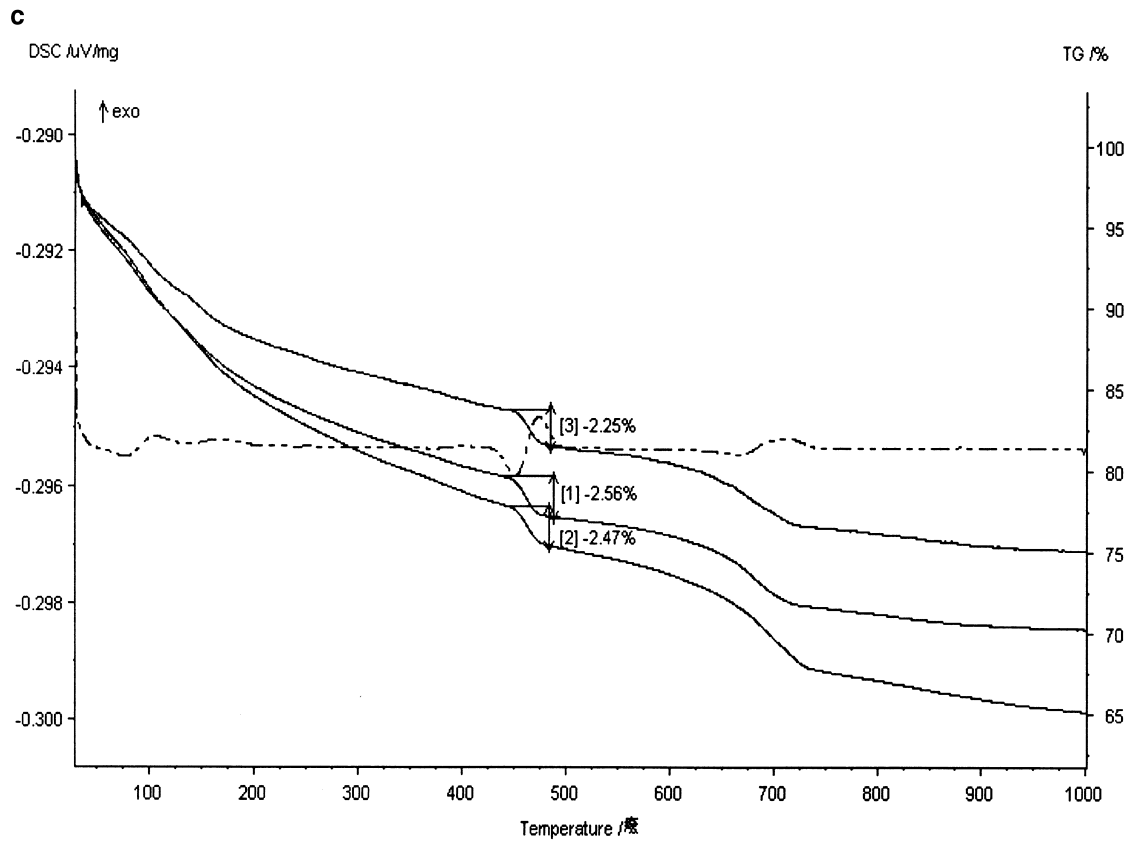

Fig. 3. (*continued*)

3.2.2. The TG analysis

Fig. 3 demonstrates the TG patterns of hydrated samples by the NETZSCH-STA 409 EP thermal analysis instrument. TG patterns of white Portland cement hydrated product show that the weight loss of $Ca(OH)_2$ about 450°C [2] is 3.12%, 3.59% and 3.72%, respectively, after 3 days, 7 days and 28 days. It shows that $Ca(OH)_2$ is increased along with the hydrated age; the TG patterns of white cement with 5% K admixture show that the weight loss of $Ca(OH)_2$ is 2.90%, 2.97% and 3.10%, respectively, after 3 days, 7 days and 28 days. $Ca(OH)_2$ was decreased when the K admixtures is mixed in it; the TG patterns of white cement with 5% L admixture show that the weight loss of $Ca(OH)_2$ is 2.56%, 2.47% and 2.25%, respectively, on 3 days, 7 days and 28 days. The quantity of $Ca(OH)_2$ gradually lessens along with the hydrated time. We can see that K and L admixtures have the capability of antialkalifying.

3.2.3. The SEM analysis

The SEM photos of hydrated samples show that there are hexagonal plank-shaped $Ca(OH)_2$, [2,4] needle-shaped AFt and colloids (Fig. 4). Much $Ca(OH)_2$ exists in the hydrated samples of white Portland cement. When the admixture is mixed in it, the quantity of $Ca(OH)_2$ is less than pure white Portland cement. $Ca(OH)_2$ is difficult to find in 28-day hydrated samples of the white Portland cement with admixture L.

The conclusion from the three measurements above are: hydration product $Ca(OH)_2$ of white Portland cement can react with SiO_2 and Al_2O_3, producing hydrated calcium silicates and hydrated calcium aluminates. It induces $Ca(OH)_2$ to be consumed. As a result, the hydration process of the cement is accelerated, the strength is advanced and the alkalization of colored Portland cement is restrained effectively.

4. Conclusions

1. L and K admixtures can react with $Ca(OH)_2$ of white Portland cement hydration, and the alkalization of white and colored Portland cement are restrained effectively.
2. The white Portland cement with K and L admixtures has higher strength than the pure white Portland cement.
3. L and K admixtures can reduce the cost of white cement and provide good economy and society benefit.

Fig. 4. SEM photos of hydrated samples. (a) The white Portland cement. (b) The white Portland cement with 5% admixture. (c) The white Portland cement with 5% K admixture.

Acknowledgments

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