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Influence and mechanism of zeolite on the setting and hardening process of styrene-acrylic ester/cement composite cementitious materials

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HIGHLIGHTS

- Zeolite shortens the initial and final setting time of SAE-cement.
- Zeolite increases the early-strength of SAE-cement effectively.
- Zeolite promotes the hydration of SAE-cement.
- Zeolite can transform into AFt and C-S-H gel in SAE-cement.

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ABSTRACT

This paper aims to solve the problem of retardation existing in the setting and hardening process of styrene-acrylic ester/cement composite cementitious materials (short for SAE-cement). It was found that zeolite could shorten the initial and final setting time of SAE-cement and increase its early-strength effectively. The hydration heat, hydration degree and hydrates of SAE-cement were analyzed by using isothermal calorimeter and XRD analyzer in order to analyze the function mechanism of zeolite in SAE-cement. The results showed that zeolite could promote the hydration of SAE-cement, significantly shorten the induction period of this cement and improve its hydration degree. Besides, it was found that zeolite could transform into AFt and C-S-H gel in the SAE-cement. Faster hydration and more AFt and C-S-H gel formation make the setting and hardening process of SAE-cement faster.

1. Introduction

Cement is one of the most popular building materials nowadays. To make its performance better in some special scenarios and meet higher requirements, polymer-cement composite cementitious material appears. This kind of new cementitious material has better comprehensive properties [1–8], such as impermeability, frost resistance, corrosion resistance and flexural strength. It does very well in the fields of concrete repair, waterproof materials, decorative mortar and pavement [9–12]. However, after modified by polymer, the setting and hardening process of cement is retarded significantly, which affects its applications sometimes. So currently to accelerate the setting and hardening process can make the polymer-modified cement be applied in more areas.

Though there are many setting accelerators which can fix this problem, more problems come like serious dry shrinkage and notable strength decline [13–16]. And these accelerators are usually very expensive and it is uneconomic to use a large amount in engineering [17,18]. So it is essential to find a new modifier which is cheap, efficient and has no side effect. Zeolite is a kind of cheap and easy-mined natural mineral, which is very rich in China. It is a hydrous aluminum silicate mineral and contains a range of 70%–80% of active SiO_2 and Al_2O_3. Zeolite is often in the shape of short columns and in the form of micro-crystals, and has large internal surface area, excellent absorption ability and ion exchange property. Due to its unique characteristics and strong pozzolanic reaction [19–21], zeolite may accelerate the hydration of cement and improve its mechanical properties and durability. So, zeolite may be a good choice for the polymer-modified cement.

This paper studies the accelerating effect of zeolite on the setting and hardening process of SAE-cement in macro by using the setting time and early-age compressive strength development,

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Table 1
Chemical composition of the P·II 52.5R Portland cement (% by weight).

CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3	K_2O	Na_2O	TiO_2	f-CaO
62.1	20.7	4.76	3.33	1.20	2.57	0.85	0.33	0.26	0.28

Table 2
Mineral composition of the P·II 52.5R Portland cement (% by weight).

C_3S	C_2S	C_3A	C_4AF	$CaSO_4$
61.36	13.14	6.98	10.12	4.36

and its influence on hydration process by using isothermal calorimeter and the hydrates by using XRD analyzer.

2. Experimental

2.1. Raw materials

Materials used include PII 52.5R Portland cement. Styrene-acrylic ester (SAE) latex, zeolite powder and pure water. The chemical and mineral compositions of the cement are shown in Tables 1

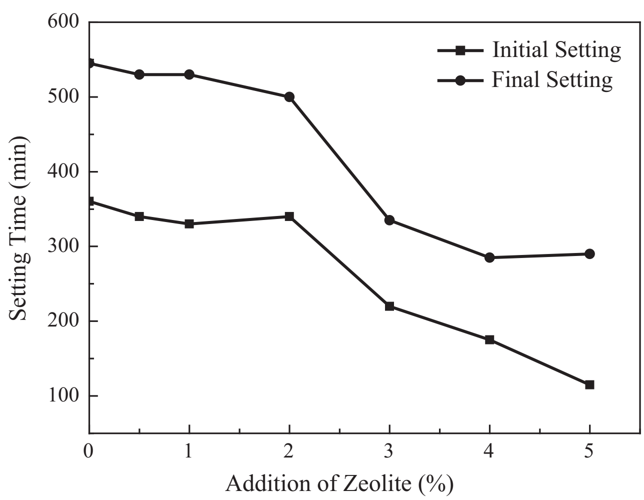

Fig. 1. The relationship between the setting time and addition of zeolite in SAE-cement.

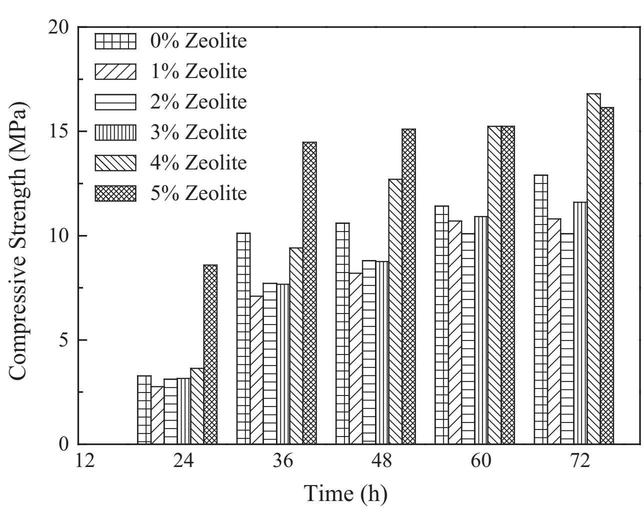

Fig. 2. The relationship between the compressive strength and addition of zeolite in SAE-cement.

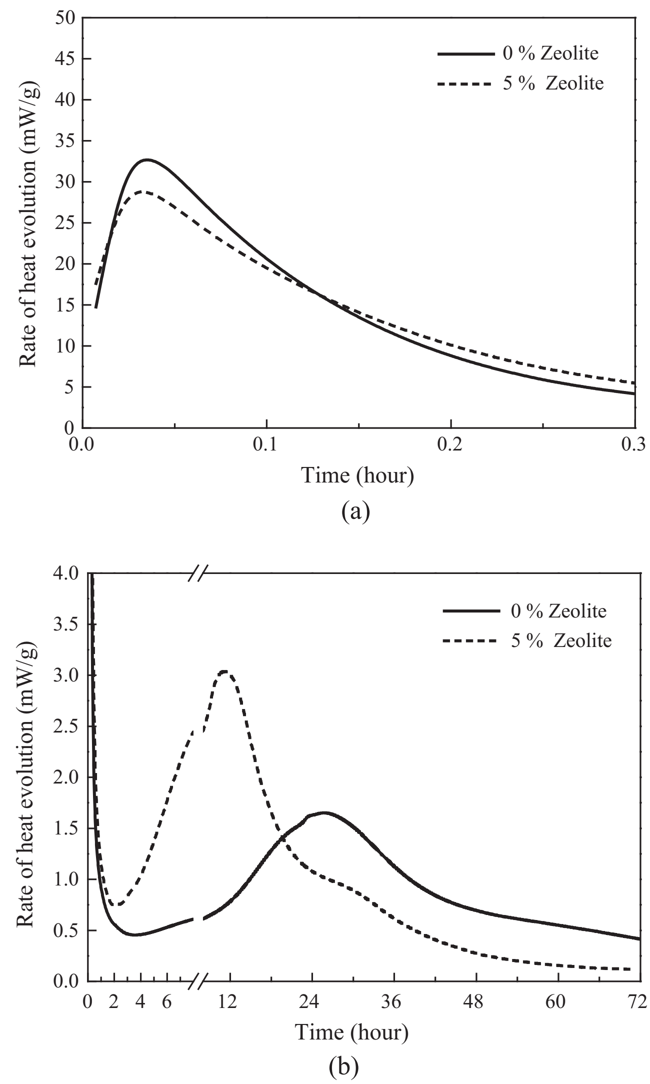

Fig. 3. Rate of heat evolution of SAE-cement hydration with 5% and without zeolite.

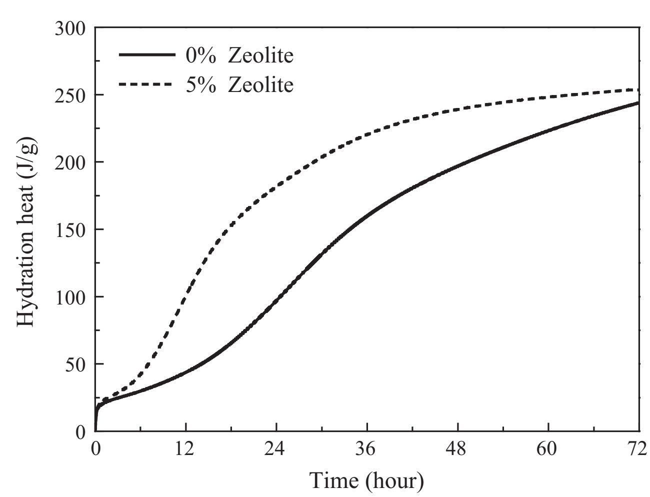

Fig. 4. Hydration heat of the SAE-cement with 5% and without zeolite.