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Effect of lithium salt and nano nucleating agent on early hydration of cement based materials

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HIGHLIGHTS

- The lithium salt and nano material are used to accelerate the early hydration.
- The early strength of cement is studied by studying the early hydration degree.
- The durability is researched to verify the effect on the properties.

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ABSTRACT

The purpose of this paper is to study the effects of lithium salt and nano nucleating agent on the properties of cement-based materials, including early hydration, early strength and long-term strength of cement-based materials. The results were as follows: There is a large increase of lithium to cement early hydration, lithium sulfate effect on early hydration of cement than lithium nitrate. Lithium content of 0.3‰ can be very good to promote the early hydration of cement to improve the early strength. nano nucleating agent can significantly improve the early hydration of cement, and the rate of hydration of cement will increase with the increase of the content of nano nucleating agent. However, with the addition of nano nucleating agent, the slurry becomes thick, so adding proper amount of early strength water reducing agent can increase the fluidity of the slurry and improve the performance of the slurry.

1. Introduction

With the development of building industrialization [1–3], prefabricated components have been used more and more in construction. Precast concretes for the early release of strength have a high demand, and they need to achieve more than 50% of the concrete design strength in the short term. In order to improve the early strength of concrete and meet the requirement of demoulding of prefabricated parts, the steam curing method has been widely used in the early maintenance of prefabricated components.

Steam curing of concrete can be divided into four stages, including static stop heating, cooling, constant temperature and constant temperature time, generally in 6–10 h, constant temperature at 60–80 °C [4–7], steam curing time total in 14 h or so. After the steam curing the strength can meet the basic requirements of prefabricated demoulding. Steam curing can greatly shorten the curing time, so as to shorten the production cycle and improve the mold turnover efficiency. Therefore, the steam curing was widely used in prefabricated buildings, but the steam curing method still exists some problems. Due to the higher curing temperature at early stage, the early hydration of concrete accelerated, which resulted in a larger void between the hydrated products. With the continuous development of the strength, these pores has not been filled. In the specimen, it can affect the late strength of concrete, the slow development of the late strength of concrete, and even retraction phenomenon. At the same time, the durability of concrete will have an adverse effect. Of course, steam maintenance requires a large amount of fuel to provide temperature and humidity, which greatly increases the cost of concrete and is not conducive to sustainable development.

As the steam curing has a series of disadvantages, how to improve the early hydration degree of cement has become the

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Table 1
Chemical composition of cement.

Composition	Al_2O_3	SiO_2	P_2O_5	SO_3	CaO	K_2O	TiO_2	Fe_2O_3	MnO
Contents/%	7.91	19.50	6.70	4.10	57.50	0.89	0.17	3.00	0.10

focus of research. Many studies showed that [8–12], the early hydration of cement is due to the slower induction period, and the protective film theory produced many scholars agree the induction period of reason, therefore, starting from the destruction of protective film in order to improve the hydration degree of cement is a good method. The small radius of lithium ion has a good destructive effect on the protective film formed by cement hydration. nano materials [13–15] can be well as nucleation sites provide nucleation sites for the hydration products of cement due to the small size. It can reduce the cement hydration product in the cement particle surface accumulation to accelerate the hydration degree of cement.

This paper mainly introduces the effects of the lithium salt and nanomaterials on the early hydration of cement and the hydration heat of hydration degree. Also, the specimen strength and durability were verified, so as to obtain the proper content.

2. Raw materials and mix proportion

2.1. Cement

The cement in this research is P·II 52.5 from Jiang Nan Xiao Ye Tian cement factory. The specific surface area and apparent density of cement is 370 m^2/kg and 3.10 g/cm^3. the bulk density is 1.02 g/cm^3. Its chemical composition is shown in Table 1.

2.2. Sand

Sand: fineness modulus Mx = 2.28, belonging to the sand, the bulk density of sand is 1.47 g/cm^3, apparent density of the sand is 2.62 g/cm^3. Sand gradation is shown in Table 2.

Table 2
Sand gradation.

Particle size /mm	2.36–4.75	1.18–2.36	0.6–1.18	0–0.6
Mass fraction /%	21.11	14.06	34.88	29.95

2.3. Lithium salts and nanoscale nucleating agents

Lithium sulfate: Level of analytically pure, the purity is more than 99.5%.

Lithium nitrate: Level of analytically pure, the purity is more than 99.5%.

Nano silica: Level of analytically pure, the purity is more than 99.5%, fineness at 50 nm ± 5 nm.

Nano $CaCO_3$: Level of analytically pure, the purity is more than 99.5%, fineness at 50 nm ± 5 nm.

2.4. Mix proportion

In this paper, the water to cement ratio is 0.5 and the cement to sand ratio is 1:3.

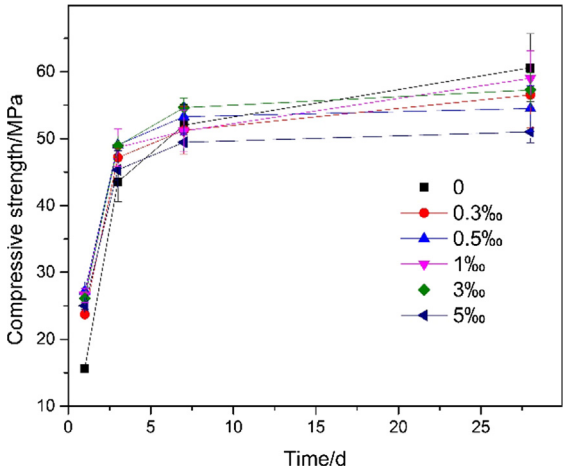

Fig. 2. The strength development of cement paste with the addition of lithium sulfate.

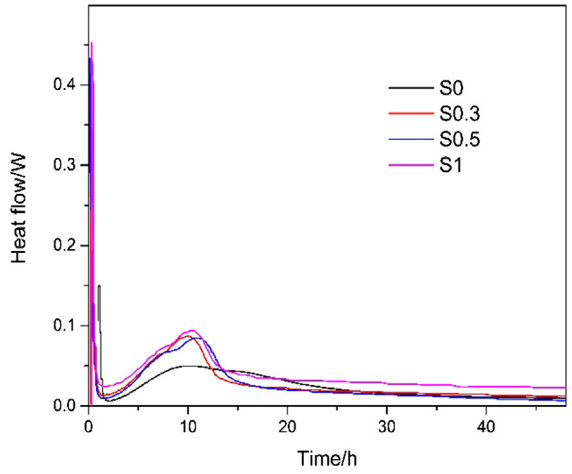

Fig. 1. Effect of lithium sulfate on hydration of cement in early stage.

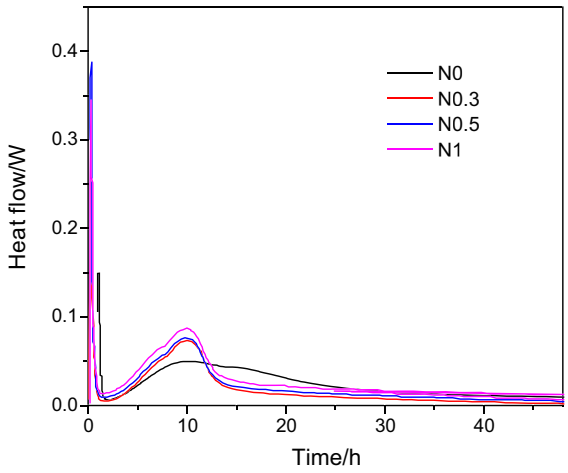

Fig. 3. Effect of lithium nitrate on hydration of cement in early stage.