The effect of setting retarder composition on the setting times of concrete

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Abstract. Retard is a kind of admixture to delay the concrete hardening. There are a lot of different kinds of retards. The research aims to investigate the effect of different retards on the setting times of concrete. In the paper, the effect of the type and dosage of retards on the setting times of concrete will be systematically researched. This research will provide a guidance for the usage of different retards.

Keywords: Retarder, concrete, setting time.

1. Introduction

The most common cement setting retarder used in industry is natural gypsum, which is primarily a dihydrated product of calcium sulfate. The need for gypsum in cement increases with increasing amount of C3A and alkalies in the clinker and the fineness of the cement[1–3]. Gypsum also promotes cement strength at an optimum content value[4].

Gypsum quarries are steadfastly moving into mining rock that is a mixture of gypsum and anhydrite. Partial replacement of the gypsum with anhydrite is possible for the majority of types of clinker. Hence, anhydrite is used in cements with a low aluminate content and in slag cements. The slower dissolution of anhydrite may have adverse effects on the setting of cements with a high alkali or aluminate content [1,5].

Concrete admixtures such as set retarding is increasingly used in the construction industry. Their addition to concrete is helpful to adjust the setting times of concrete. Composition of these admixtures is most commonly based on lignosulfonic or hydroxy-carboxylic acids, or their modifications or derivatives or less commonly on carbohydrates, heptonates, or phosphates. Several theories have been offered to explain the mechanism of retardation[1-3]. Put simply, the admixtures function by forming a film around the cement grains thereby preventing or slowing the reaction with water. The thickness of this film will dictate the degree to which the rate of hydration is retarded. After a while, this film breaks down and normal hydration proceeds. However, there are many factors that can influence the degree of retardation [1,3- 8]. These include the water/cement ratio, cement content, and so on.

2. Materials

The cement was used Portland cement CEM-1 42.5, and its chemical and physical properties are shown in Table 1 and 2. The fly ash and slag were used as supplementary cementing material. The river sand with 2680 kg▪m-3 apparent density and 2.8 fineness modulus was used as fine aggregate. The other components were tap water and polycarboxylate superplasticizer (PCE) using as water reducing agents.

Table 1 Chemical compositions of cement (wt./%)

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2Oeq	LOI	f-CaO	Cl-
21.32	4.31	3.38	61.26	2.47	2.55	0.57	1.31	0.86	0.014

Table 2 Physical properties of cement

Density / $kg \cdot m^{-3}$	Specific surface / $kg \cdot m^{-3}$	Setting time / min		Flexural strength / MPa		Compressive strength / MPa	
		Initial	Final	3 d	28 d	3 d	28 d
3160	340	99	159	5.7	8.8	26.2	50.4

2.1 Preparation of specimen

The mix proportion of concrete specimen with different dosage of different kinds of retards were shown in Table 3.

2.2 The test method of concrete's setting times

The concrete mixture is screened out of the test mortar through a 5 mm round hole screen, and the mortar is covered immediately after the shaking table is shaken for 3 s ~5 s, and the concrete mixture is tested at a temperature of (20±2) ℃. The setting time starts from the concrete mixing and adding water. Use the measuring needle to test once every 1 h, and then shorten the test interval when the initial and final coagulation are approaching. In data processing, the penetration resistance value was taken as the longitudinal coordinate and the test time as the horizontal coordinate. The relationship curve between the penetration resistance value and time was drawn. When the penetration resistance value reached 3.5MPa, the corresponding time was taken as the initial setting time. When the value of penetration resistance reaches 28 MPa, the corresponding time is taken as the final setting time.

3. Results and discussion

3.1 The effect of dosage of retards on the initial setting times of concretes

The slumps of concrete were controlled at 220 mm through adjusting the PCE's dosage to keep the workability of concrete. As shown in the Figure 1, it can be seen that with the dosage of seignette salt increasing from 0.25%~1.20%, the initial setting times of concrete was increasing too. When the dosage of seignette salt were over 0.80%, the initial setting time of concrete were over 48 h. However, when the dosage of seignette salt was less than 0.60%, the initial setting times of concrete was increasing linearly with the increase of its dosages.

As shown in the Figure 2, it can be seen that with the dosage of β-CD increasing from 0.20%~0.50%, the initial setting times of concrete was increasing too. When the dosage of β-CD were over 0.20%, the initial setting time of concrete were around 100 h. Comparing with seignette salt, it seems like the β-CD showed stronger retarding capability.

It can be found in the Figure 3, it can be seen that with the dosage of saccharose increasing from 0.10%~0.20%, the initial setting times of concrete was also increasing. When the dosage of saccharose were over 0.18%, the initial setting time of concrete were over 100 h. It showed strong retarding capability.

Table 3 Concrete mix proportion (kg/m3)

Specimen	PCE	Fly ash	slag	Cement	Coarse aggregate （5～20）mm	Fine aggregate	Water	Retard	Dosage of retard
F-0	1.6	70	80	330	1000	830	160	seignette salt	0.25%
F-1	1.3	70	80	330	1000	830	160		0.30%
F-2	1.5	70	80	330	1000	830	160		0.35%
F-3	1.4	70	80	330	1000	830	160		0.40%
F-4	1.6	70	80	330	1000	830	160		0.45%
F-5	1.6	70	80	330	1000	830	160		0.50%
F-6	1.2	70	80	330	1000	830	160		0.80%
F-7	1.4	70	80	330	1000	830	160		1.20%
P-0	1.4	70	80	330	1000	830	160	sodium gluconate	0.50%
P-1	1.6	70	80	330	1000	830	160		1.00%
C-0	1.6	70	80	330	1000	830	160	β-CD	0.20%
C-1	1.5	70	80	330	1000	830	160		0.30%
C-2	1.6	70	80	330	1000	830	160		0.40%
C-3	1.3	70	80	330	1000	830	160		0.50%
Z-0	1.6	70	80	330	1000	830	160	saccharose	0.10%
Z-1	1.3	70	80	330	1000	830	160		0.12%
Z-2	1.6	70	80	330	1000	830	160		0.14%
Z-3	1.2	70	80	330	1000	830	160		0.18%
Z-4	1.6	70	80	330	1000	830	160		0.20%

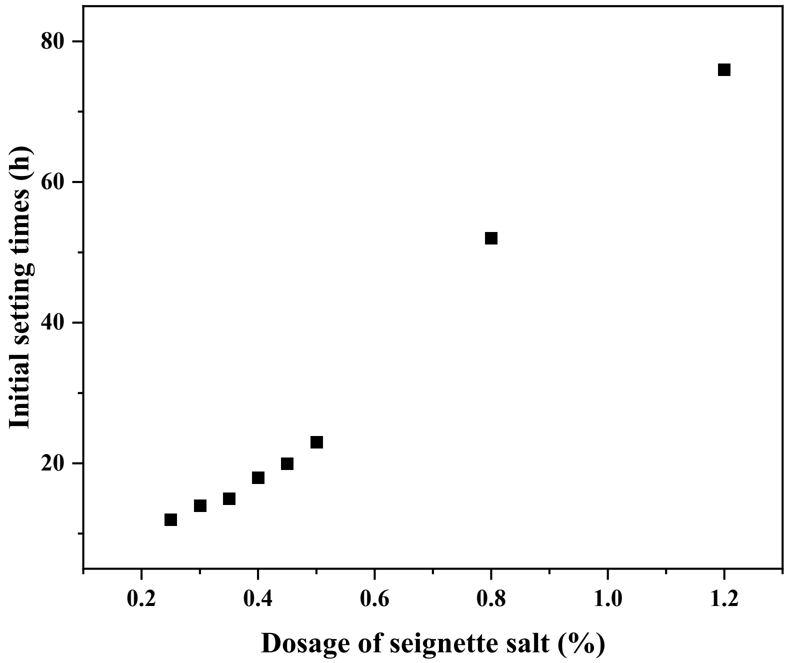

Figure 1 The initial setting time of concrete containing seignette salt

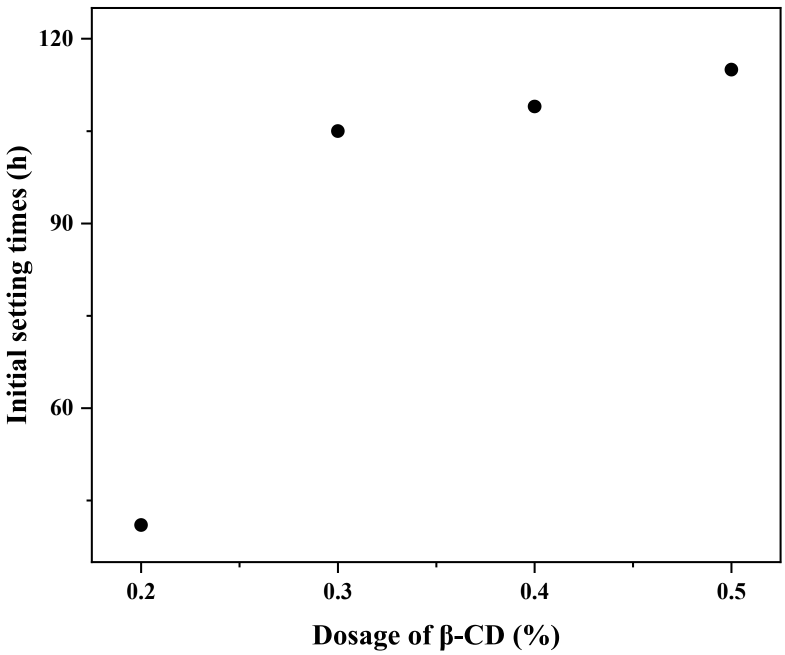

Figure 2 The initial setting time of concrete containing β-CD

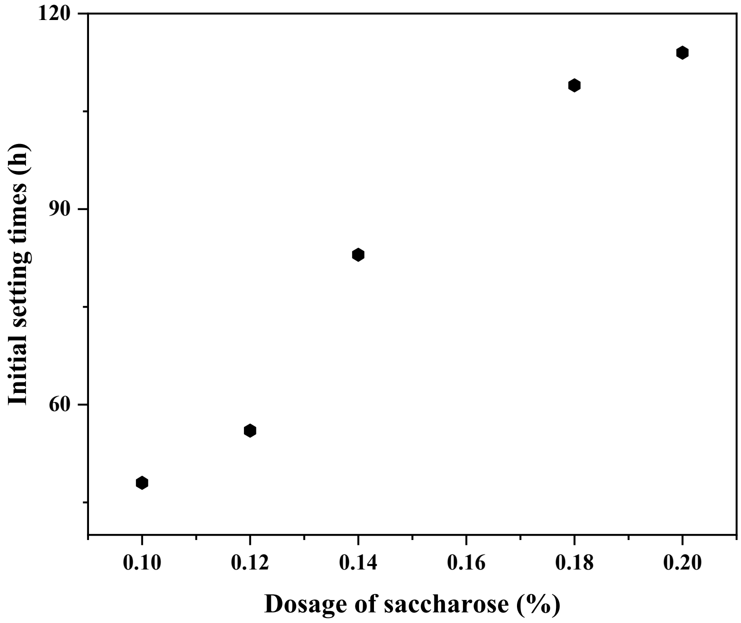

Figure 3 The initial setting time of concrete containing saccharose

4. The effect of the kind of retard on the initial setting times of concrete

As shown in the Figure 4, it can be seen that the concrete's initial setting time with different kinds of retards at the same dosage (0.20%). It can be found that the order of concrete setting times was following: saccharose＞ β-CD ＞ sodium gluconate ＞ seignette salt. the dosage of β-CD increasing from 0.20%~0.50%, the initial setting times of concrete was increasing too. When the dosage of saccharose was 0.20%, the initial setting time of concrete were over 100 h. Comparing with other retarders, the saccharose showed stronger retarding capability.

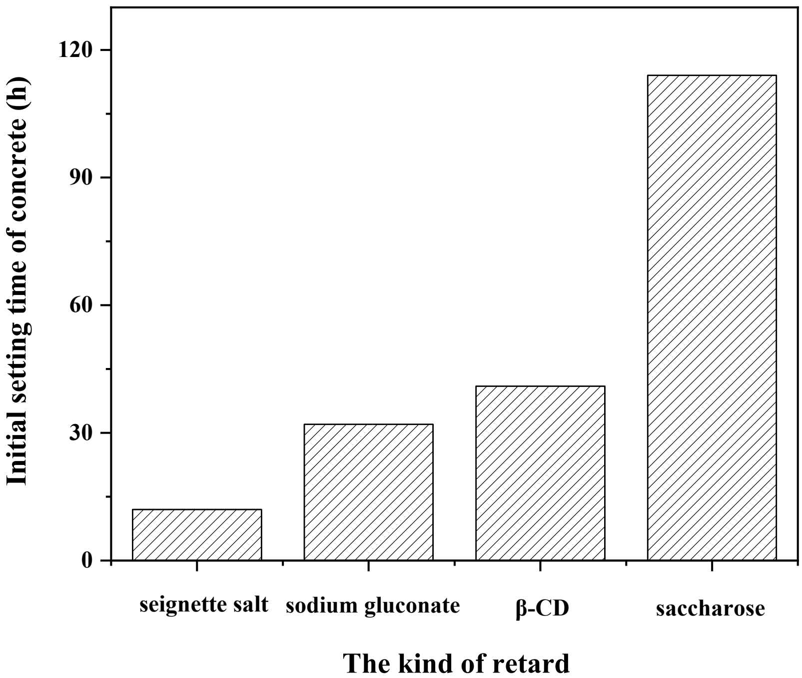

Figure 4 The setting times of concrete containing different kinds of retarders

5. Conclusion

Through adjusting the type of retarder, the setting times of concrete have changed a lot, and it can be found that the order of concrete setting times was following as: saccharose＞ β-CD ＞ sodium gluconate ＞ seignette salt. Comparing with other retarders, the saccharose showed the strongest retarding capability.

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