The preparation of ultra-retarding concrete through using super retarder

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Abstract. Ultra-retardation concrete is a kind of concrete, which can change the setting time over a long period of time by adjusting the dosage of retarder, without damaging the concrete performance, and its later strength is affected by the high dosages of retarder. At present, ultra-retardation concrete is mainly used in deep foundation pit support structures in high-rise buildings and subway construction processes, and ultra-large volume concrete with special requirements for concrete setting time, such as ultra-long diameter underwater pile foundation engineering. It has a wide range of application advantages in the construction of interlocking piles in subway stations and other areas. In this paper, we want discuss the preparation of ultra-retarding concrete through using super retarder.

Keywords: Retarder, Concrete, Support Structures.

1. Introduction

With the continuous development of cities and the utilization of underground space, the demand for ultra-slow setting concrete in construction projects is increasing day by day. Ultra-slow setting concrete is a kind of concrete with special slow setting performance. Its setting time is very long, even more than 72 hours, while maintaining good workability for a certain period of time, and concrete still has sufficient strength and durability after setting and hardening[1]. This kind of retarding performance makes the super retarding concrete have good flow performance, easy construction, and can adjust the solidification time within a certain range, and the construction efficiency is high. In practical engineering applications, ultra-slow setting concrete is generally used for new type of traffic coagulation

Soil engineering can effectively solve the problem of process connection in special parts of the project.At present, the key preparation process of ultra-slow setting concrete is the use of admixtures. Ordinary concrete retarders such as sodium gluconate can generally only extend the setting time from several hours to more than ten hours[2]. If the mixture ratio of concrete is too much concrete retarder, although it can prolong the setting time of concrete, it will lead to the aggregate settlement stratification of concrete. In addition, overmixing of retarding agent will cause the loss of free water in concrete bleeding, resulting in uneven distribution of water inside the concrete, affecting the strength and durability of the surface concrete and even the whole part[3], resulting in hidden dangers in quality. Therefore, the key to the preparation of super slow setting concrete lies in the selection and application of super slow setting water reducer, and at the same time ensure the concrete has reasonable durability and strength.

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_2O_{eq}	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.

Table 3 Concrete mix proportion (kg/m^3)

Specimen	PCE	Fly ash	slag	Cement	Coarse aggregate （5～20） mm	Fine aggregate	Water	Retarder	Dosage of retard
F-2	1.5	70	80	330	1000	830	160	seignette salt	0.20%
F-3	1.4	70	80	330	1000	830	160		0.30%
P-0	1.4	70	80	330	1000	830	160	sodium gluconate	0.20%
P-1	1.6	70	80	330	1000	830	160		0.30%
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%
Z-3	1.2	70	80	330	1000	830	160	saccharose	0.20%
Z-4	1.6	70	80	330	1000	830	160		0.30%

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.

2.3 Mechanical properties test of concrete

The compressive strength of concrete was tested according to GB/T 50081-2019. The concrete specimen size is 100 mm × 100 mm × 100 mm. When the concrete specimen reaches the age of 7 d, 14 d and 28 d from the time of mixing and adding water, the specimen is taken out of the standard curing room, the clear water on the surface of the specimen is wiped off, the specimen is placed in the middle of the upper and lower pressure plate of the press, and the load is evenly loaded at the specified speed until the specimen is destroyed, the failure load is recorded, and the compressive strength value is calculated.

3. Results and discussion

3.1 The effect of different dosages and types of retarders on the setting times of concretes

The slumps of concrete were fixed at 220 mm through controlling the dosage of PCE's. Then the setting times of concrete in the presence of different retarders were investigated. The dosages of retarders were 0.20% and 0.30%, respectively. As shown in the Figure 1, it can be seen that concrete's initial setting time with different kinds of retarders at the same dosage (0.20%) were totally different. It can be found that the order of concrete setting times was following: saccharose＞ β-CD ＞ sodium gluconate ＞ seignette salt. Moreover, with content of retarder increasing, the initial setting times of concrete have been also prolonged. Especially, for saccharose, when the dosage of saccharose was over 0.20%, its initial setting time was over 120 h.

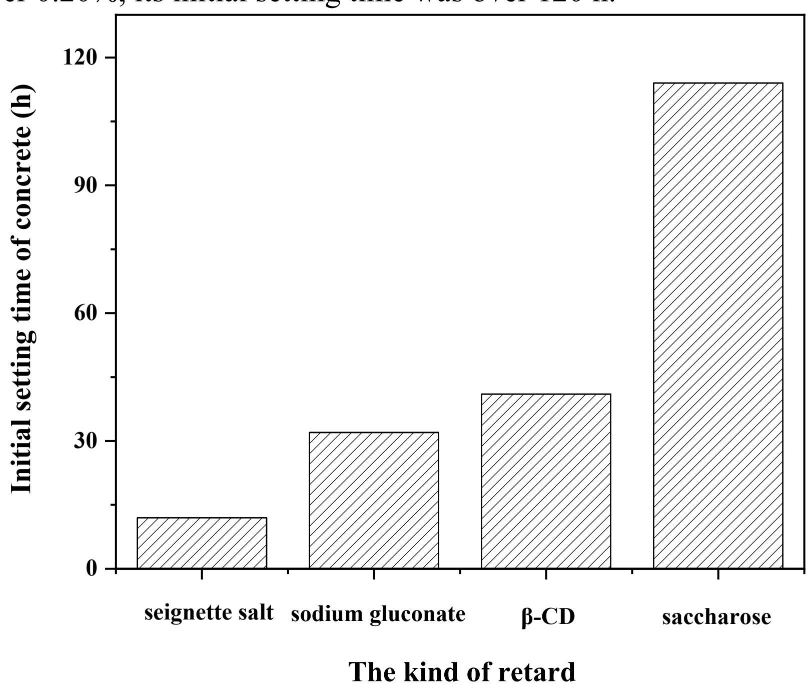

Figure 1 The initial setting time of concrete containing different kinds of retarders (dosage was 0.20%)

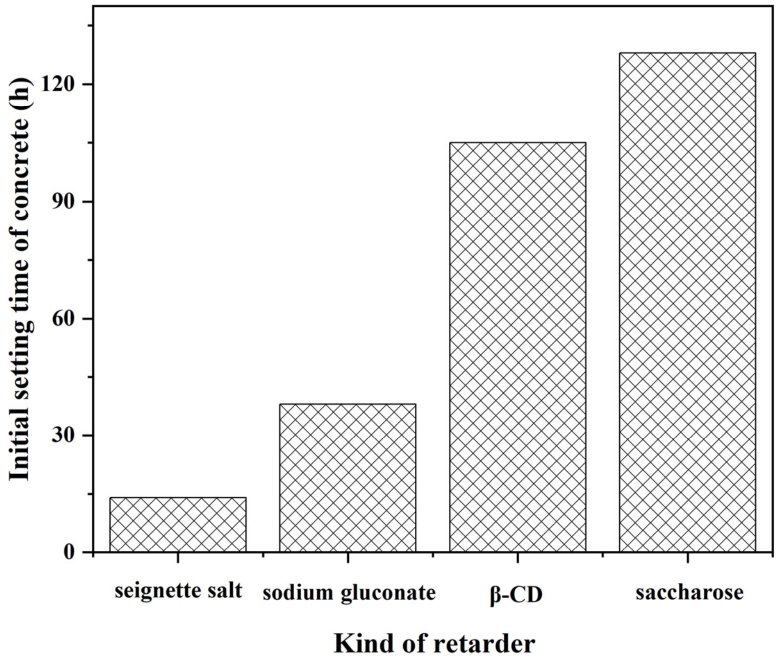

Figure 2 The initial setting time of concrete containing different kinds of retarders (dosage was 0.30%)

The effect of different dosages and types of retarders on the final setting times of concretes were also researched. For ultra-retarding concrete, its final setting time has to be less than 120 h, and the initial setting time needs to be more than 60 h. The final setting times of concrete with different retarders were shown in Figure 3 and Figure 4. It can be found that the saccharose and β-CD were more suitable for the preparation for the ultra-retardation concrete. Therefore, the saccharose was used as ultra-retarder for the preparation of ultra-retardation concrete.

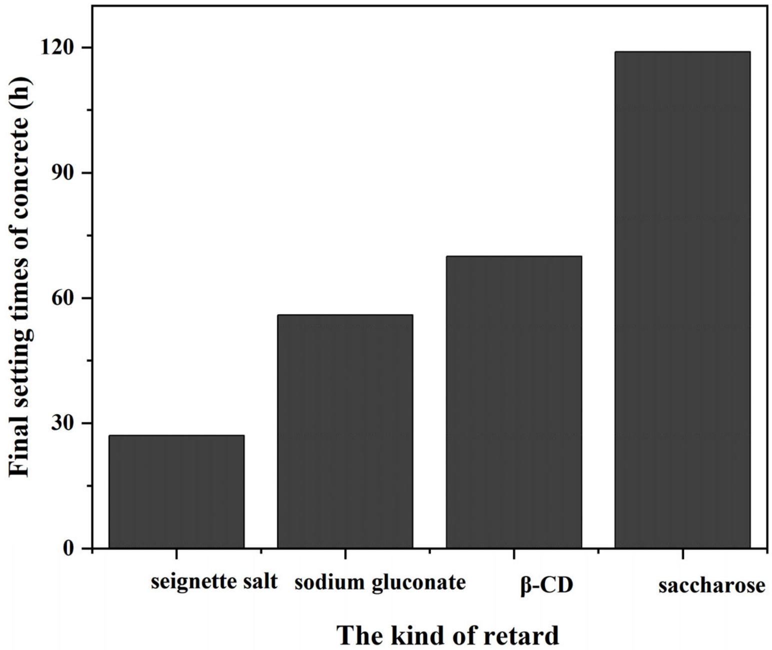

Figure 3 The initial setting time of concrete containing different kinds of retarders (dosage was 0.20%)

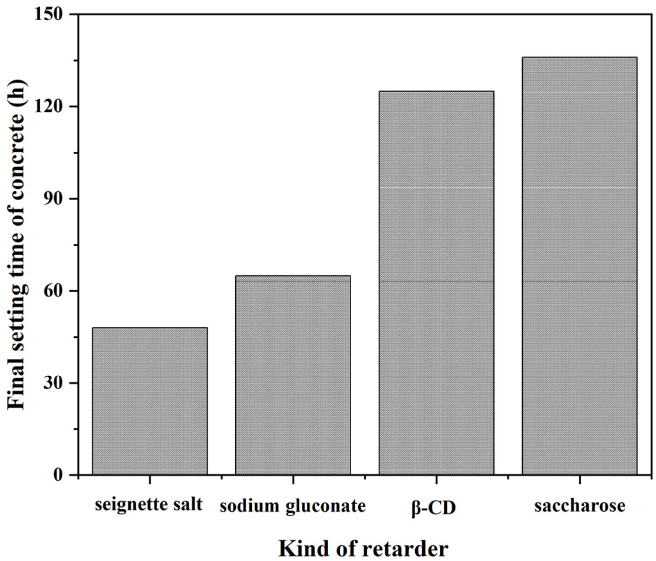

Figure 4 The initial setting time of concrete containing different kinds of retarders (dosage was 0.30%)

3.2 The strength of concrete with ultra-retarder

The strength of concrete is the most important parameter of concrete, so the strength of concrete in the presence of ultra-retarder, and the results were shown in Figure 5, it can be found that with curing time increasing, the strength of concrete was also increased. When the curing time was at 28d, the strength of concrete was 44 MPa, which is content with the C35 concrete's strength demanding.

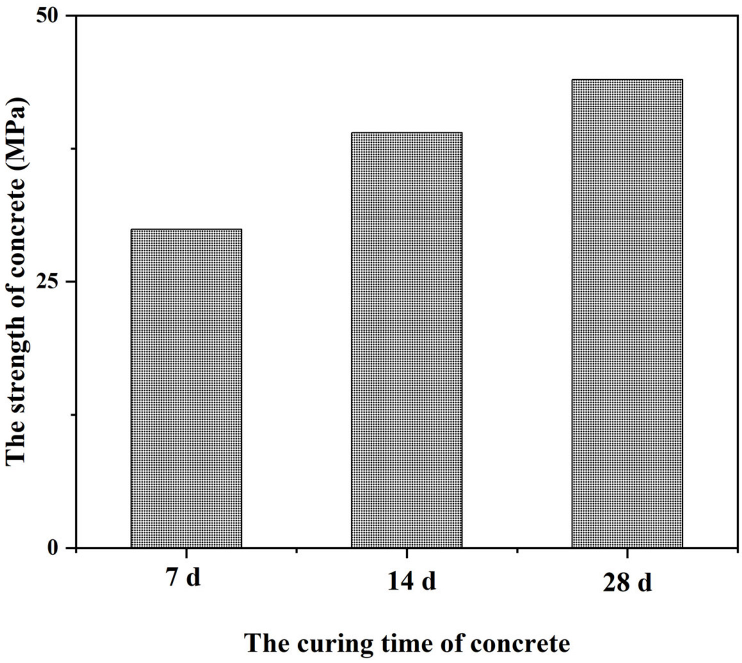

Figure 5 The curing time of concrete

4. Conclusion

Through adjusting the type of retarder, the setting times of concrete have changed a lot. More importantly, by the use of the suitable retarder, the concrete's final setting time was less than 120 h, and the initial setting time was more than 60 h. And the strength of concrete was 44 MPa, which is content with the C35 concrete's strength demanding.

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