Research on the Application of slump retaining Polycarboxylic Acid in Concrete

Haili Qiu

KZJ New Materials Group Fujian Co., Ltd., Zhangzhou, Fujian, 363100, China

Corresponding author's e-mail: 497193524@qq.com

Abstract. Starting from the causes of concrete slump loss and the polymerization mechanism of different types of polycarboxylic acid water reducing agents, this paper introduces the effects of different gradient slump retaining polycarboxylic acid and water reducing polycarboxylic acid combinations in polycarboxylic acid admixtures on the fluidity of cement paste and its temporal changes, the fluidity of concrete changes over time, compressive strength, and concrete state.The experimental results indicate that slump retaining polycarboxylic acid can effectively control the loss of concrete slump and ensure construction requirements. However, excessive slump retaining polycarboxylic acid in polycarboxylic acid admixtures can lead to lagging of concrete admixtures, thereby affecting concrete quality and construction requirements.

Keywords: concrete, slump resistant polycarboxylic acid.

1 Introduction

Japanese catalyst companies were the first to develop polycarboxylate water reducing agents in the 1980s.1984, Japan Eokada et al. [1] from Hon Hua Wang Company invented superplasticizers.In the 1990s, Master Builder Tech synthesized a high- performance water reducing agent with good initial dispersion and excellent slump retention [2]. Polycarboxylic acid admixtures have green and environmentally friendly production processes and can be designed with molecular structures. Compared to naphthalene and aliphatic water reducing agents, they have more diverse functionalities and can better serve concrete production enterprises [3]. The raw materials for synthesizing polycarboxylic acid mainly include alkenyl macromers and acrylic acid, among which macromers become the molecular side chains of polycarboxylic acid water reducing agents, providing steric hindrance and giving them good dispersibility to achieve water reducing effect. Therefore, the structure and performance of large monomers are one of the key factors affecting the synthesis and performance of polycarboxylate water reducing agents [4-8]. In addition, small monomers such as acrylic acid, hydroxyethyl acrylate, hydroxypropyl acrylate, and sodium methacrylate sulfonate can endow polycarboxylate water reducers with various functional characteristics such as slow re-

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lease and early strength, and are also important components of polycarboxylate water reducers [9-12].

With the gradual depletion of natural resources, the raw materials required for concrete production have encountered bottlenecks. In order to break this bottleneck, machine made sand has completely replaced natural sand. Machine made sand itself is composed of various substances, therefore, the different content of components in machine made sand will have an impact on the overall performance of concrete. Overall, the lithology, particle characteristics, stone powder content, and MB value of the parent rock in machine-made sand can all have a certain impact on the performance of concrete [13], especially the problem of loss of concrete fluidity. In order to solve the problem of large loss of concrete fluidity, the main solution is to increase the proportion of slump retaining polycarboxylic acid in polycarboxylic acid admixtures. This ensures the requirements of concrete construction and effectively avoids resource waste.

This article compares the effects of different gradient slump retaining polycarboxylic acids and water reducing polycarboxylic acids on the performance of concrete through slurry tests and concrete tests, providing reference for concrete enterprises.

2 Experimental raw materials and methods

2.1 Raw material

Cement: Fujian Chunchi P.O42.5R, code C, cement performance indicators are detailed in Table 1.

Table 1. Cement Performance Indicators

setting time/min		Compressive strength/MPa		Flexural Strength/MPa		stability
Initial setting	Final set	3d	28d	3d	28d	
215	271	26.9	47.8	5.0	7.2	qualified

Fly ash: Class II ash from Fujian Houshi Power Plant, code F, with a fineness of 21.2%, water demand ratio of 98%, loss on ignition of 1.23%, activity index of 79%, and stability of 1.2mm.

Mineral powder: Tangshan Caofeidian Shield Stone New Building Materials Co., Ltd. S95 grade, code K, its performance indicators are detailed in Table 2.

Table 2. Performance indicators of mineral powder

density/(g/cm^3)	Specific surface area/(m^2/kg)	activity index/%		Liquidity ratio/%	loss on ignition/%	Initial setting time ratio/%
		7d	28d			
2.89	440	81	98	109	0.2	111

Fine aggregate: Machine made sand is used as the fine aggregate, code S, fineness modulus 2.8, grading interval II, MB value 1.75, stone powder content 4.4%, and crushing value index 16.9%.

Coarse aggregate: 5-31.5mm continuously graded crushed stone, code G, with a crushing index of 9.4% and a mud content of 0.4%.

Polycarboxylic acid mother liquor: The performance indicators of polycarboxylic acid mother liquor are detailed in Table 3.

Table 3. Performance indicators of admixtures

Mother liquor type	appearance	Containing solids/%	pH
Collapse proof type	Colorless Transparent Liquid	50	5.0
Water reducing type	Colorless Transparent Liquid	50	5.5

The mixing water is tap water, code W.

The concrete test adopts the C30 strength grade, and the mix ratio is detailed in Table 4.

Table 4. C30 Concrete Mix Propor Unit: kg/m^3

W	admixture	C	F	K	S	G
160	6.12	250	60	30	804	1066

2.2 Experimental methods

The performance of concrete shall be tested in accordance with the "Standard Test Methods for Performance of Ordinary Concrete Mixtures" (GB/T 50080-2016) and the "Standard for test methods of concrete physical and Mechanical Properties " (GB/T50081-2019). The cement paste experiment was conducted in accordance with the " MethodS for testing Uniformity of Concrete Admixtures" (GB/T 8077-2012), with 300g of cement and 87g of water.

3 Results and Analysis

3.1 Cement paste test

The fluidity of mud slurry was compared. Under the condition of maintaining the same total amount of polycarboxylic acid admixtures, the initial fluidity and time changes of cement slurry with different gradient slump maintaining polycarboxylic acid and water reducing polycarboxylic acid in polycarboxylic acid admixtures were compared. The specific situation is detailed in Table 5.

Table 5. Experimental Data of Cement Paste

number	Admixture dosage/%	Proportion of water reducing type/%	Proportion of collapse protection type/%	0h Fluidity/mm	2h Fluidity/mm	4h Fluidity/mm	notes
A1	1.0	20	0	201	Immobile	Immobile	-
A2	1.0	20	1	203	Immobile	Immobile	-
A3	1.0	20	2	202	135	Immobile	-
A4	1.0	20	4	206	189	Immobile	-
A5	1.0	20	6	208	210	Immobile	-
A6	1.0	20	8	208	245	140	-
A7	1.0	20	10	212	280	240	Bleeding
A8	1.0	20	15	212	288	278	Bleeding
A9	1.0	20	20	215	320	335	Bleeding

From Table 5, it can be seen that:

- With the continuous increase of the proportion of slump retaining polycarboxylic acid, the initial fluidity of cement slurry will also increase, indicating that the slump retaining polycarboxylic acid mother liquor has a water reduction rate, but the water reduction rate is relatively small;
- With the continuous increase of the proportion of slump preserving polycarboxylic acids, the flowability of cement paste shows an amplification trend during aging. The larger the proportion of slump preserving polycarboxylic acids, the more obvious the amplification; Paragraphs should be justified;
- With the continuous increase of the proportion of slump retaining polycarboxylic acids, the change in cement paste over time becomes smaller;
- The proportion of slump retaining polycarboxylic acid exceeds 10%, and the cement slurry shows a delayed bleeding phenomenon, indicating that a higher proportion of slump retaining polycarboxylic acid is not better.

3.2 Concrete testing

The experimental temperature of concrete is 22.5 ℃, and the relative humidity is 74%. Under the condition of maintaining the same total amount of polycarboxylic acid admixtures, the effects of different gradient slump retaining polycarboxylic acid and water reducing polycarboxylic acid admixtures on the expansion of concrete and their changes over time, as well as compressive strength, are studied. The specific situation is detailed in Table 6.

Table 6. C30 Concrete Test

number	Proportion of water reducing type/%	Proportion of collapse protection type/%	Slump/Expansion/ mm			compressive strength/MPa		notes
			0h	2h	4h	7d	28d	
B1	20	0	200/520	/	/	28.3	37.8	/
B2	20	1	210/525	/	/	27.8	38.0	/
B3	20	2	210/530	140/0	/	28.6	37.5	/
B4	20	4	210/545	180/310	/	28.6	38.2	/
B5	20	6	215/550	200/440	/	27.9	37.5	/
B6	20	8	220/560	210/520	155/0	28.6	38.1	/
B7	20	10	220/560	210/560	210/420	26.9	37.0	Bleeding and bottoming
B8	20	15	225/565	210/580	215/580	26.5	37.5	Bleeding and bottoming
B9	20	20	225/565	220/610	210/590	26.0	36.9	Bleeding and bottoming

From Table 6, it can be seen that:

- As the proportion of slump retaining polycarboxylic acid increases, the initial expansion of concrete gradually increases, and this trend is proportional to the proportion;
- As the proportion of slump retaining polycarboxylic acid increases, the initial slump of concrete gradually increases, indicating that slump retaining polycarboxylic acid can improve the initial workability of concrete;
- From B7, B8, and B9, it can be seen that with the increase of the proportion of slump retaining polycarboxylic acids, the expansion of concrete shows an amplification phenomenon and the loss shows an overmixing phenomenon of admixtures;
- With the increase of the proportion of slump retaining polycarboxylates, there is no adverse effect on the compressive strength of concrete.

4 Conclusion

With the complexity of concrete raw materials, the proportion of slump retaining polycarboxylic acid in the composite formula of polycarboxylic acid admixtures continues to increase, which effectively controls the loss of concrete fluidity and meets the actual construction needs of the construction site. At the same time, it should also be recognized that the increase in the proportion of slump retaining polycarboxylic acids may pose a risk of delayed over mixing of admixtures, causing concrete loss to be amplified, delayed bleeding, and bottom grasping, thereby affecting concrete quality and construction requirements. Therefore, in practical engineering applications, it is necessary to develop appropriate polycarboxylate admixtures based on the characteristics of concrete materials, construction requirements, climatic conditions, and transportation distance, in order to ensure the quality of concrete and construction requirements.

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