Effect of Early Strength, Retarding and Slump-retaining Components of Polycarboxylic Acid Admixture on Workability of Fresh Concrete

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Abstract. The effects of the amount of early strength components, retarding components and slump-retaining components of concrete admixtures on initial fluidity, slump loss and initial setting time of concrete are compared through experiments, so as to adjust the workability of fresh concrete more pertinently.

1. Introduction
The excellent water-reducing performance of polycarboxylic acid water-reducing agent has been widely recognized by the industry\cite{1}. However, due to the complex and changeable requirements of practical engineering, it is difficult to meet the requirements of early strength, long-time retarding and long-time slump-retaining by using polycarboxylic acid water-reducing agent alone\cite{2}. Therefore, it is often necessary to compound early strength components, retarding components and slump-retaining components in polycarboxylic acid admixture to solve different problems\cite{3-5}.

The early strength components of polycarboxylic acid admixtures can accelerate the development of early strength of concrete and the hydration speed of cement. They are suitable for steam cured concrete and concrete projects with early strength requirements under normal, low and minimum temperatures not less than -5°C\cite{6}.

The retarding components in polycarboxylic acid admixture can retard the hydration and heat release of cement, keep the plasticity of fresh concrete in a certain period of time and prolong the setting time of concrete. It is suitable for mass concrete, concrete constructed in hot climate, concrete poured in large area, concrete avoided from cold joints and other concrete that need to prolong the retarding time\cite{7}.

The slump-retaining components of polycarboxylic acid admixture can make the concrete slump not lose quickly and keep the plasticity of concrete for a long time\cite{8}.

In this paper, the effects of early strength components, retarding components and slump-retaining components of polycarboxylic acid admixtures on the initial slump, slump loss and initial setting time of fresh concrete are studied.

2. Experimental
2.1. Materials
Cement(C): Hua Run P.O 42.5R cement($R_{c}=52Mpa$); Sand(S): river sand (Finess modulus 3.0, mud content 1.8%); Small stone(G1): gravel(The particle size ranges from 5 mm to 20 mm and the mud content is 0.5%); Big Stone(G2): gravel(The particle size ranges from 16 mm to 31.5 mm and
the mud content is 0.4%;); Mineral powder(K): The specific surface area is 412 m²/kg and R₂₈ is 97%; Fly ash(FA): Fineness 18%, R₂₈ is 76%; Water reducer(PC): Polycarboxylic acid water reducing agent produced by KZJ, the water reducing rate was 27% when the dosage was 2.0%; Early strength components(Z): KZJ Early Strength Agent; Retarding components(H): KZJ retarder; Slump-retaining components(B): KZJ slump retaining agent.

2.2. Concrete performance test method
According to GB/T 50080-2016 Standard for Testing Methods of Performance of Ordinary Concrete Mixtures, the initial slump TL₀, initial expansion TK₀, concrete 1 hour slump TL₁ₙ, concrete 1 hour expansion TK₁ₙ, concrete slump 1 hour variation ΔTL and concrete initial setting time T are tested. The concrete mix used in the test is shown in Table 1.

### Table 1. Concrete mix ratio
| W  | C  | S  | G₁ | G₂ | FA | K  |
|----|----|----|----|----|----|----|
| 166| 266| 813| 499| 499| 35 | 49 |

3. Experimental results and discussion

3.1. Effect of early strength components on the properties of fresh concrete
Under the condition of keeping the dosage of other components in polycarboxylic acid admixture unchanged, the dosage of early strength components in polycarboxylic acid admixture was adjusted, and the total amount of polycarboxylic acid admixture obtained by mixing was the same by adjusting the dosage of water. Using the concrete mix ratio shown in table 1, the dosage of polycarboxylic acid admixture was 2.0%. The effect of the dosage of early strength components on the performance of fresh concrete was investigated. The experimental results are shown in Table 2.

### Table 2. Effect of early strength components on the properties of fresh concrete

| The dosage of Z/% | TL₀/mm | TK₀/mm | TL₁ₙ/mm | TK₁ₙ/mm | ΔTL/mm | T/min |
|-------------------|--------|--------|----------|----------|---------|-------|
| 0                 | 190    | 430    | 80       | -        | 110     | 480   |
| 5                 | 190    | 430    | 75       | -        | 115     | 450   |
| 10                | 190    | 430    | 80       | -        | 110     | 440   |
| 15                | 190    | 430    | 75       | -        | 115     | 430   |
| 20                | 185    | 430    | 60       | -        | 125     | 430   |
| 0                 | 190    | 430    | 80       | -        | 110     | 480   |

The experimental results show that the content of early strength components in polycarboxylic acid admixture has little effect on the initial fluidity, 1 hour fluidity and the loss of concrete slump in 1 hour. With the increase of the amount of early strength components in polycarboxylic acid admixture, the initial setting time of concrete tends to be slightly shortened. This is mainly because the early strength components are mainly used to improve the early strength of concrete, which has little effect on the fluidity of concrete, and there is not necessarily a clear relationship between the early strength and the initial setting time.

3.2. Effect of retarding components on properties of fresh concrete
Under the condition of keeping the dosage of other components in polycarboxylic acid admixture unchanged, the dosage of retarding components in polycarboxylic acid admixture was adjusted, and the total amount of polycarboxylic acid admixture obtained by mixing was the same by adjusting the dosage of water. Using the concrete mix ratio shown in table 1, the dosage of polycarboxylic acid admixture was 2.0%. The effect of the dosage of retarding components on the performance of fresh concrete was investigated. The experimental results are shown in Table 3.

### Table 3. Effect of retarding components on the properties of fresh concrete

| The dosage of H/% | TL₀/mm | TK₀/mm | TL₁ₙ/mm | TK₁ₙ/mm | ΔTL/mm | T/min |
|-------------------|--------|--------|----------|----------|---------|-------|
| 0                 | 190    | 430    | 80       | -        | 110     | 480   |
| 0.5               | 190    | 430    | 110      | -        | 80      | 550   |
| 1.0               | 195    | 440    | 110      | -        | 85      | 610   |
The experimental results show that the content of retarding components in polycarboxylic acid admixture have little effect on the initial fluidity of concrete, but with the increase of retarding components content, the time-varying amount of concrete slump in 1 hour decreases slightly, indicating that increasing the amount of retarding components has a certain effect on reducing the time-varying loss of concrete slump. With the increase of the amount of retarding components, the initial setting time of concrete is obviously prolonged. This is mainly because retarding components are mainly used to delay the hydration of cement, which has little effect on the initial fluidity of concrete. However, because they delay the hydration of cement, they offset part of the slump loss of concrete and obviously delay the initial setting time of concrete.

3.3. Effect of slump-retaining components on properties of fresh concrete

Under the condition of keeping the dosage of other components in polycarboxylic acid admixture unchanged, the dosage of slump-retaining components in polycarboxylic acid admixture was adjusted, and the total amount of polycarboxylic acid admixture obtained by mixing was the same by adjusting the dosage of water. Using the concrete mix ratio shown in table 1, the dosage of polycarboxylic acid admixture was 2.0%. The effect of the dosage of slump-retaining components on the performance of fresh concrete was investigated. The experimental results are shown in Table 4.

| The dosage of B/% TL₀/mm TK₀/mm TL₁h/mm TK₁h/mm ΔTL/mm T/min |
|-----------------|----------|----------|----------|----------|----------|----------|
| 0               | 190      | 430      | 80       | -        | 110      | 480      |
| 5               | 185      | 430      | 130      | -        | 55       | 490      |
| 10              | 190      | 430      | 165      | -        | 25       | 500      |
| 15              | 195      | 445      | 185      | 380      | 10       | 520      |
| 20              | 190      | 440      | 195      | 430      | -5       | 540      |

The experimental results show that the content of slump-retaining components in polycarboxylic acid admixture have little effect on the initial fluidity of concrete, but with the increase of the amount of slump-retaining components, the time-varying amount of concrete slump in 1 hour decreases significantly. When the content of slump-retaining components is 20%, the time-varying amount of concrete slump in 1 hour also appears negative value, which indicates that increasing the content of slump-retaining components can significantly reduce the time-varying loss of concrete slump, even without loss or increase. With the increase of the content of slump-retaining components, the initial setting time of concrete is slightly prolonged, which indicates that the slump-retaining components can affect the setting of concrete to a certain extent. This is mainly due to the fact that the slump-retaining components can reduce the time-varying amount of concrete slump by slowly releasing water-reducing groups under alkaline conditions after adding concrete to compensate for the loss of water-reducing agents in the hydration process, thus achieving the effect of reducing the time-varying amount of concrete slump in 1 hour, and also having a slight retarding effect.

4. Conclusions

(1) The content of early strength components in polycarboxylic acid admixture has little effect on the initial fluidity, 1 hour fluidity and the loss of concrete slump in 1 hour. With the increase of the amount of early strength components in polycarboxylic acid admixture, the initial setting time of concrete tends to shorten slightly.

(2) The content of retarding components in polycarboxylic acid admixture have little effect on the initial fluidity of concrete, but with the increase of retarding components content, the time-varying amount of concrete slump in 1 hour tends to decrease slightly, and the initial setting time of concrete obviously prolongs.

(3) The content of slump-retaining components in polycarboxylic acid admixture have little effect on the initial fluidity of concrete, but with the increase of slump-retaining components, the
time-varying amount of concrete slump in 1 hour decreases obviously and the initial setting time of concrete prolongs slightly.

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