Application of viscosity-reducing Polycarboxylate Superplasticizer in PHC Pumping Pipe Pile Production

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Abstract. Using 3-methyl-3-buten-1-ol polyoxyethylene ethers (the TPEG), acrylic acid (AA), methyl acrylate (MA) monomer, ammonium persulfate (APS) and hydrogen peroxide Vitamin C- (Vc-H2O2) composite initiation, thioglycolic acid (TGA) as a chain transfer agent, a reduced viscosity polycarboxylate superplasticizer (PCE-RV) was synthesized by aqueous solution free radical polymerization. The test and comparison and economic benefit analysis of the viscosity-reducing polycarboxylic acid high performance water reducer applied to PHC pipe piles were carried out.

1. Introduction
At present, the skilled piles of the pipe piles are losing quickly, the recruitment is difficult, and the labor costs are continuously improved, which has a great adverse impact on the production cost and production efficiency of the pipe pile enterprises.

Under this influence, how to optimize the production process and improve production efficiency have received wide attention in the industry. Some large domestic pipe pile production enterprises have begun to apply fluidized concrete to the PHC pipe pile production field, and use the fluid concrete pumping process to carry out automatic production of PHC pipe piles.

The transportation of concrete by pumping can save the labor operation of the pipe pile concrete in the process of producing the cloth, thereby saving labor costs. Among them, realizing the automatic cloth is the key link of the pumping pipe pile production process.

The introduction of pumping concrete into the closed-die feeding technology of the pipe pile can greatly reduce the number of labor and labor intensity before the production of the pipe pile, but it also brings many adverse effects, such as many pipe pile enterprises due to pumping concrete The performance is not in place, causing many problems in the production process. Low efficiency and low production capacity have seriously hindered the development of the pipe pile industry. It is especially important to control the technical control of PHC pipe pile pumping concrete in the production process of pipe piles [1].

2. Experimental
2.1. Materials

2.1.1. The main synthetic experimental raw materials
3-methyl-3-buten-1-ol polyoxyethylene ether (TPEG), monomer relative molecular mass 2400, hydrogen peroxide (H2O2), industrial grade; vitamin C (Vc), industrial grade; ammonium persulfate
(APS), industrial grade; methyl acrylate (MA), industrial grade; thioglycolic acid (TGA), industrial grade; 30% sodium hydroxide solution (NaOH), industrial grade;

2.1.2. Main performance test raw materials for experiment
Cement (C): Conch 52.5 P·II Portland cement.
Gravel (G): crushed stone granite, and there are 5 ~ 10mm 10 ~ 20mm two kinds of grain size.
Sand (S): MX = 2.7 sand, clay content of 0.8%, an apparent density of 2620kg / m³, a bulk density of 1450kg / m³.
Silica powder (the GSS), a specific surface area 4120cm²/g, a silicon content of 94.3%, loss on ignition 0.83%.
Polycarboxylate superplasticizer (PCE-1): Commercially available integrated Polycarboxylate.
Polycarboxylate superplasticizer (PCE-2): Commercially available early strength polycarboxylate superplasticizer.
Polycarboxylate superplasticizer (PCE-3): Commercially available esters of polycarboxylate superplasticizer.
Polycarboxylate superplasticizer (PCE-4): Commercially available highwater reduction.

2.2. Copolymerization
The metered water and TPEG are added to the four-necked bottle, and the temperature is raised to the reaction temperature. After the macromonomer is completely dissolved, hydrogen peroxide is added, and the aqueous solution of the initiator APS, the aqueous solution of AA and HEA, and the aqueous solution of the initiator Vc are separately added dropwise. And the aqueous solution of the molecular weight regulator TGA is controlled to be dripped for a certain period of time, and then the temperature is kept for 1-2 hours, and the pH value is adjusted to 5.0-7.0 by adding NaOH, thereby obtaining the viscosity-reducing polycarboxylic acid water reducing agent PCE-RV.

2.3. Performance test method
Cement paste fluidity measurement "concrete admixture homogeneity test" in accordance with GB / T8077-2012.
The fresh concrete slump performance through inverted slump cone emptying time index to evaluate, the test method according to GB / T 50080-2016 "ordinary concrete mixture Standard Performance Test Method."
The concrete compressive strength test is evaluated according to the method specified in GB/T 50081-2002 "Standards for Testing Mechanical Properties of Ordinary Concrete". The test block size is 150mm × 150mm × 150mm.

3. Experimental results and discussion
3.1. Paste fluidity test
The PCE-1, PCE-2, PCE-3, PCE-4, and PCE-RV were tested according to the method of GB/T8077 according to the 0.5% dosage and the slurry flow rate was 1 h. The test results are shown in Figure. 1.
It can be seen from Fig. 1 that the 0 min paste fluidity of PCE-RV is comparable to that of PCE-1 and PCE-2, and it is better than PCE-4 and PCE-2 at 60 min. It is comparable to PCE-3 in 120 min paste fluidity.

3.2. Effect of polycarboxylate type on PHC pumping pipe pile
By comparing the properties of the polycarboxylate mother liquor, the pumping performance, steaming strength and autoclave strength were observed. The test concrete mix ratio is shown in Table 1[2]. The test results are shown in Figure 2 and Table 2.

| W (kg/m³) | C (kg/m³) | GSS (kg/m³) | S (kg/m³) | G5~10mm (kg/m³) | G10~20mm (kg/m³) |
|-----------|-----------|-------------|-----------|-----------------|------------------|
| 144       | 330       | 130         | 802       | 320             | 776              |

Figure 1. Comparative fluidity of cement paste.

Figure 2. Slump and Flow Test
Table 2. Pumping PHC pipe pile test results

| Sample  | Steaming strength | Autoclaved strength | Fallen slumping time/s | Workability          |
|---------|-------------------|---------------------|------------------------|----------------------|
| PCE-1   | 46.4              | 89.7                | 13.3                   | More pulp            |
| PCE-2   | 52.3              | 87.3                | 12.2                   | Softer               |
| PCE-3   | 48.2              | 93.2                | 10.2                   | Softer               |
| PCE-4   | 47.4              | 88.3                | 14.8                   | Sticky and difficult to pump |
| PCE-RV  | 47.7              | 91.3                | 9.4                    | Slurry is full and easy to pump |

It can be seen from Fig. 2 that the PCE-RV viscosity-reducing mother liquor retains the 30-min extension with good initial expansion. Table 2 shows that the PCE-RV slurry is full and easy to pump \[3\]. The emptying time of the slump cylinder is 9.4s, and the steaming strength reaches 47.7MPa, and the autoclave strength reaches 91.3MPa.

3.3. Pumping PHC pipe pile trial production

The PHC pipe pile pumping trial production was carried out by adjusting the PCE-RV viscosity reducing polycarboxylic acid type high performance water reducing agent \[3\]. Trial production of three 15m pipe piles, from the pumping speed comparison, the pumping speed is 30.5 kg / s, 34.0 kg / s, 36.1 kg / s, pumping speed is good, the pumping speed data is shown in Table 3.

Table 3 PHC pumping pipe pile production data

| Production code | Pumping weight (kg) | Pumping time (s) | Pumping speed (kg/s) |
|-----------------|---------------------|------------------|----------------------|
| SC-01           | 5980                | 196              | 30.5                 |
| SC-02           | 4460                | 131              | 34.0                 |
| SC-03           | 5130                | 142              | 36.1                 |

The comprehensive production time of pumping fabrics is about 3 minutes, which can save nearly half of the time compared with the traditional cloth method of 6min, which improves the production efficiency and reduces the loss of production equipment in the production process.

The three pipe piles produced by trial production showed an average strength of 46.0 MPa from the results of steaming strength. From the viewpoint of autoclave strength, SC-02 was 88.3 MPa, and the autoclaved strength ratio was the best. The trial production intensity results are shown in Figure 3.
4. Economic Benefit Analysis

For example, a pipe pile production enterprise with a monthly output of 100,000 meters requires 4 PHC pipe pile production lines, which are produced by ordinary admixtures. It requires about 20 production line workers and about 230 tons of ordinary admixtures per month. The production of special admixture for pipe piles requires 8 production line workers and the use of admixtures is about 120 tons. With ordinary admixtures of 2,400 yuan per ton, pumping pipe piles with admixtures of 4,500 yuan per ton, and workers' wages of about 7,000 yuan per month as the benchmark, the economic benefits before and after the use of pumping pipe pile special admixtures are analyzed. The 100,000-meter pipe pile production enterprise can save 96,000 yuan per month. The comparison data is shown in Table 4.

|                      | Before use (yuan/month) | After use (yuan/month) | Estimated savings (yuan/month) |
|----------------------|-------------------------|------------------------|--------------------------------|
| Naphthalene          | 552,000                 | 140,000                | 96,000                         |
| Labor cost           | 540,000                 | 56,000                 |                                |

By using the pumping pipe pile admixture to adjust the pipe pile concrete cloth mode, the monthly production of 100,000 meters pipe pile production enterprise is estimated to save 96,000 yuan per month. In the production process of the pipe pile, the production workers can save the steps of filling and falling concrete, and the production efficiency can be greatly improved.

5. Conclusion

The viscosity-reducing polycarboxylic acid has good performances such as moisture retention performance, steam curing, autoclave strength and pumping speed, and meets the production performance requirements of pumping pipe piles.

Pumping concrete technology is the future development direction of the pipe pile industry. Compared with the traditional pipe pile industry, the fluidized concrete is introduced into the PHC pipe pile production, which makes the number of workers required for pipe pile production, labor intensity, material mold loss. The production cost has been greatly reduced, which has improved the market competitiveness of the pipe pile enterprises.

In the application of pumped pipe piles, the viscosity-reducing polycarboxylic acid has a good cost performance advantage compared with the naphthalene series. Polycarboxylate has developed into the...
current mainstream concrete water reducer product due to its good designability, high water reduction rate and environmental protection [4,5].

References
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