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Effects of TEA·HCl hardening accelerator on the workability of cement-based materials

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Abstract. The aim of the test is to research the influence rules of TEA·HCl on the workability of cement paste and concrete. Based on the features of the new hardening accelerator, an experimental analysis system were established through different dosages of hardening accelerator, and the feasibility of such accelerator to satisfy the need of practical engineering was verified. The results show that adding of the hardening accelerator can accelerate the cement hydration, and what's more, when the dosage was 0.04%, the setting time was the shortest while the initial setting time and final setting time were 130 min and 180 min, respectively. The initial fluidity of cement paste of adding accelerator was roughly equivalent compared with that of blank. After 30 min, fluidity loss would decrease with the dosage increasing, but fluidity may increase. The application of the hardening accelerator can make the early workability of concrete enhance, especially the slump loss of 30 min can improve more significantly. The bleeding rate of concrete significantly decreases after adding TEA·HCl. The conclusion is that the new hardening accelerator can meet the need of the workability of cement-based materials in the optimum dosage range.

Keywords: hardening accelerator, setting time, hydration, cement, bleeding rate

1. Introduction

In concrete construction, hardening accelerator can accelerate the hardening of concrete, can improve the early strength of the concrete [1,3], and accelerate concrete the construction schedule, so it is widely used in the modern concrete construction. In order to speed up the tension reinforcement [1,2], accelerate the turnover of template and pedestal utilization in production of concrete member, the hardening accelerators were more widely used.

Hardening accelerator is the admixture that can adjust the setting time and earlier strength of concrete, mortar and cement paste. There are many types of hardening accelerator, mainly include, inorganic salts hardening accelerator, such as salt-based chlorine series, sulfate series etc. organics hardening accelerator [1,5,12], such as lower organic acid salt(calcium formate, sodium acetate, calcium oxalate, etc.), triethanolamine, triisopropanolamine, and urea [3,9], compound hardening accelerator, such as compound of inorganic salts and organic classes, compound of many kinds of inorganic salts, and compound many kinds of organic matters [13,14].

There are three ways to improve the early strength of concrete; the first way is the use of special cement, this cement can reach the predetermined strength in a short time [4,10]. However, due to its low production and high prices are restricted not to be widely used. The second way is improving the construction and maintenance of concrete, such as hot-mix concrete, steam curing treatment methods [6]. However, this method is also the inconvenience in actual industrial production, therefore not been widely adopted. The third way is to use the early strength admixture; practice has proved that this method is the easiest and least costly method, so it has been widely adopted in the construction project [8].

On the other hand, the use of hardening accelerator has significant influence on the workability of the cement-based materials [7,11]. In order that the hardening accelerator is better applied in practical engineering, we should to have a good grasp the influence rules of hardening accelerator on the workability of the cement-based materials. TEA·HCl, as a new type hardening accelerator, prompt us to research the influence rules of it on the workability of cement paste and concrete.

2. Experimental

2.1. Raw Materials

2.1.1. Cement. P·O 42.5 ordinary portland cement was used, produced by Jidong Cement Factory, the performance of which is reported in table 1.

Table 1. Performance of the cement.

Fineness（80μm sieve residue）%	Setting Time/min		Soundness（boiling method）	Bending Strength /MPa		Compressive Strength /MPa	
	Initial	Finnal		3d	28d	3d	28d
1.7	210 >45	252 <390	Qualified	4.1 4.0	8.4 7.3	21.4 17.2	49.3 48.8

2.1.2. Superplasticizer. Polycarboxylate superplasticizer, self made polycarboxylic superplasticize was used in this test, the solid content of which is 40%. Choose the recommended dosage, the adding amount is usually 0.2% to 0.5%, tentative dosage is 0.2% (equivalent to solid dosage calculation).

2.1.3. Hardening Accelerator. TEA·HCl hardening accelerator: the hardening accelerator used in this test was self made products, 98% purity, white, crystalline powder.

2.1.4. Fine Aggregate. River sand, Region Ⅱ medium sand, its fineness modulus is 2.65, mud content is less than 2%.

2.1.5. Coarse Aggregate. Coarse aggregate: gravel, 5 mm~25 mm, continuous grading.

2.1.6. Water. Tap water was used in this test, comply with the technical requirements of standard concrete mixing water.

2.2. Experimental Methods

The water requirement of normal consistency of the cement was pre-determined according to the national standard. The initial setting time and final setting time were tested for blank samples and which was added TEA·HCl hardening accelerator with the water requirement of normal consistency. According to preliminary tests that the optimal dosage range of the hardening accelerator, the fluidity of cement paste and the loses through time were tested when the dosage of hardening accelerator is 0.03%, 0.04%, 0.05%, 0.06% and 0.07%. Thus we analyzed the influence rules of TEA·HCl on the workability of cement paste.

According *JGJ55-2011 "Specification for mix proportion design of ordinary concrete"* designed C30, C40 and C50 three strength grades of concrete mix proportion, which included blank and adding

TEA·HCl concrete. Concrete slump and the loss through time, bleeding of concrete were tested, we analyzed the influence rules of TEA·HCl on the workability of concrete.

3. Results and Discussion

3.1. Effects of Different Dosage on Setting Time

Figure 1 shows the curves for the initial setting time and final setting time of cement samples with different dosage of TEA·HCl. From figure 1, we can see that the incorporation of the hardening accelerator can accelerate the hydration of the cement, and the setting time of cement samples is not gradually shortened with the increase of the hardening accelerator in the dosage selected range. The setting time is the shortest when the dosage of 0.04%. As can be seen from table 2, the initial setting time and final setting time are 130 min and 180 min respectively, which meet the requirements of GB175-2007 "Common Portland Cement". However, they are shortened by 38.1% and 27.0% compared with the blank sample.

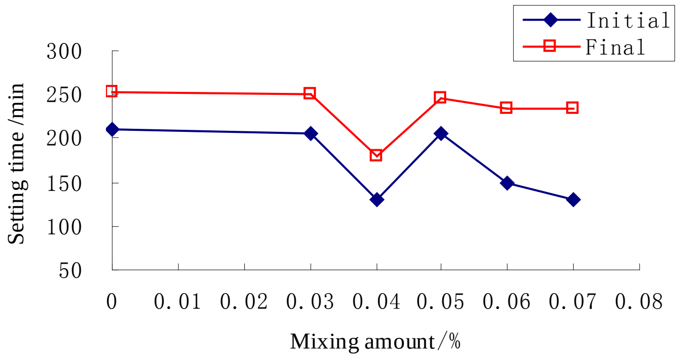

Figure 1. Setting time of cement samples with different mixing amount of TEA·HCl.

Table 2. Setting time of cement samples with different mixing amount of TEA·HCl.

Mixing Amount/ %	Initial Setting Time /min	Final Setting Time /min
0	210	252
0.03	205	250
0.04	130	180
0.05	185	245
0.06	150	235
0.07	133	215

3.2. Effects on Fluidity of Cement Paste

Figure 2 and figure 3 show the curves for the fluidity of cement paste samples with different dosage of TEA·HCl. We can see that the effects of incorporation TEA·HCl on the initial paste fluidity is not significant, but has significant improvement on the fluidity of after 30 minutes, which even larger than the initial fluidity when the dosage is more than 0.06%, the fluidity after 60 minutes would be significantly decreased with the dosage of accelerator increasing, this showed that the accelerator had plasticity-maintaining effect on the cement hydration in initial period (30 min). With time passing by (after 60 min), there would be occurred the hydration reaction accelerated, and the fluidity significantly decreased phenomenon.

3.3. The concrete slump and slump loss

The test had designed three strength grades of concrete, which included blank and adding 0.04% TEA·HCl concrete. As can be seen from table 3, with the adding of accelerator, all the workability of concrete were improved. The initial slump had some improvement, especially for the slump loses after

30 min was improved obviously. There is not much improvement for the slump loses after 60min, which is roughly equivalent compared with that of blank samples.

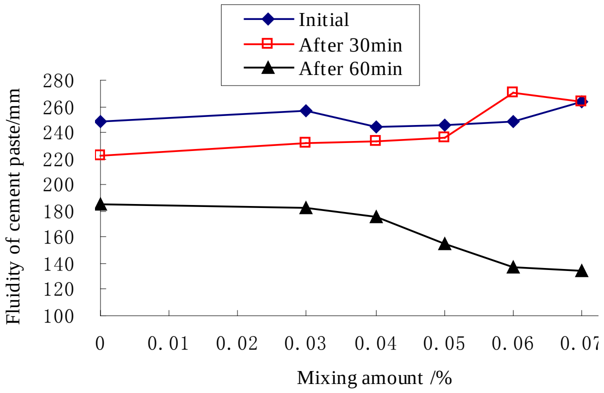

Figure 2. Fluidity of cement samples with different .

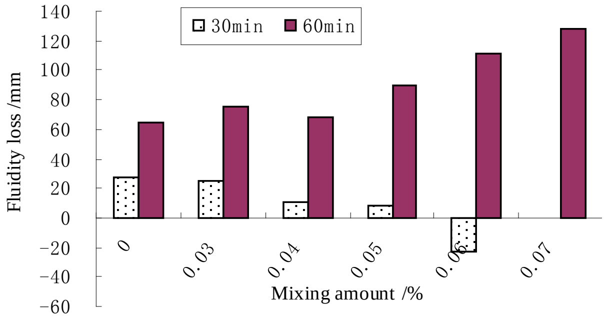

Figure 3. Fluidity loss after 30 min and 60 min mixing amount of TEA·HCl.

Table 3. Concrete slump and slump loss.

No.	Mix Proportion C:S:G:F:W	TEA·HCl /C × %	Slump/mm Initial	30 min	60 min
T3	1:2.01:3.58:0.25:0.58	0	93	68	46
T3’		0.04	95	87	53
T4	1:1.54:2.74:0.25:0.47	0	87	60	38
T4’		0.04	92	88	42
T5	1:1.22:2.17:0.25:0.39	0	99	73	39
T5’		0.04	106	95	35

This conclusion was basically consistent compared with that obtained from the cement paste fluidity test; it was that the accelerator had plasticity-maintaining effect on the cement hydration in initial period (30 min).

3.4. Bleeding Test

Bleeding test results of six groups of concrete (T3, T3’, T4, T4’, T5 and T5’) as shown in figure 4~6, we could seen that the bleeding rate of concrete was significantly decreased after adding TEA·HCl hardening accelerator, particularly more obviously after 3 hours. Taking T3 and T3’ as an example, the bleeding rate of T3’ concrete is only 42.5% of T3 concrete. This may be because that TEA·HCl accelerated the hydration of cement after mixed 1 hours.

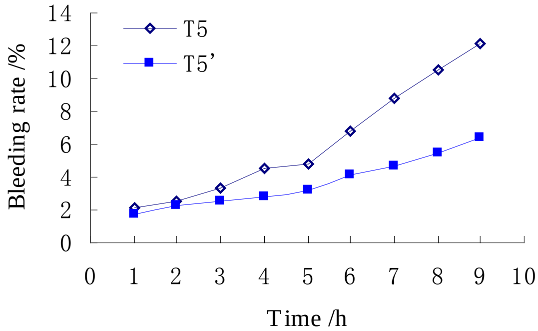

Figure 4. Bleeding rate of T3 and T3’.

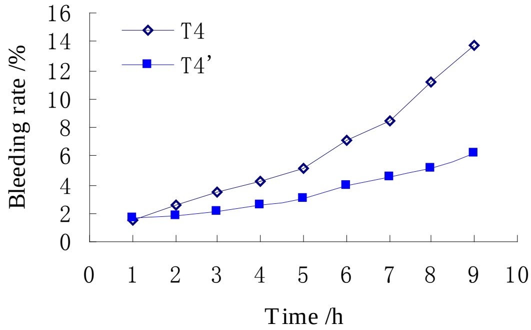

Figure 5. Bleeding rate of T4 and T4’.

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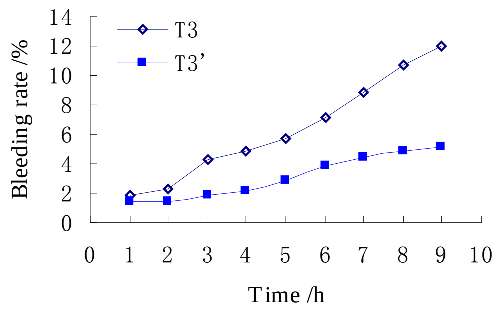

Figure 6. Bleeding rate of T5 and T5'.

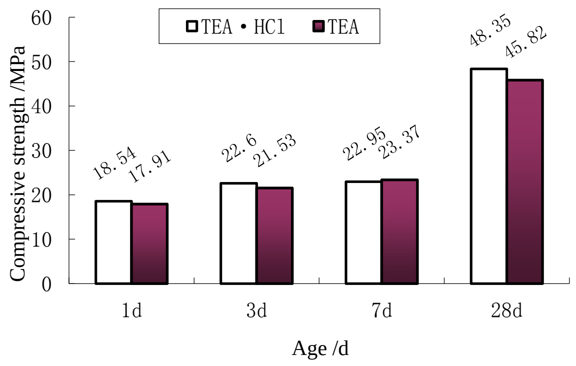

Figure 7. Comparison of compressive strength of cement mortar specimens.

3.5. Comparison of compressive strength with TEA

The strength comparative experiments were performed between the cement mortar mixed with TEA·HCl and the one with TEA. The experimental result is shown, as in figure 7.

As is shown in figure 7, we can see that the specimen strength of mixed TEA·HCl was slightly stronger than that of mixed TEA. However, the cost of TEA·HCL only accounts for about half of TEA. As for 28-day strength, the specimen strength of mixed with TEA·HCl was obviously higher than that of mixed with TEA.

4. Conclusions

Adding of the TEA·HCl hardening accelerator can accelerate the cement hydration, and what is more, when the dosage was 0.04%, the setting time was the shortest.

Adding of the TEA·HCl hardening accelerator has little effect on the initial fluidity paste, but has significant improvement on the fluidity of after 30 minutes, which is advantageous to the construction. The fluidity loss after 60 minutes increases.

After added TEA·HCl hardening accelerator, the initial slump has some improvement, especially for the slump loses after 30 min improves obviously. There is not much improvement for the slump loses after 60 min, which is roughly equivalent compared with that of blank samples.

The bleeding rate of concrete significantly decreases after adding TEA·HCl hardening accelerator.

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